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Volume II

FIGHTER AIRCRAFT OBIGGS STUDY

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NOTICE

This technical report has been reviewed and is approved for publication.

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The objective of this study was to develop a prototype development plan for installing the best choice OBIGGS in an Advanced Tactical Fighter (ATF). The best choice OBIGGS was based on detailed studies of inert gas requirements for ATF missions and trade-off studies to arrive at the best system preliminary design. Detailed specifications were defined for the best choice OBIGGS and life cycle cost studies were conducted to compare this OBIGGS with other fuel tank fire protection techniques. Results of the mission analysis and preliminary design studies are presented in Volume I; results of the other studies and the prototype development plan are in Volume II.

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PREFACE

This is the final technical report of work conducted under AFWAL Contract F33615-85-C-2545 by the Boeing Military Airplane Company, Seattle, Washington during the period from July 1985 through January 1987. Program sponsorship and guidance were provided by the Fire Protection Branch of the Aero Propulsion Laboratory (AFWAL/POSH), Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, under Project 3048, Task 07, and Work Unit 05. R. G. Clodfelter was the Government Project Engineer. Funds for the contract were provided by the Joint Technical Group on Aircraft Survivability (JTCG/AS).

The final report is contained in two volumes. Volume I contains mission analysis and preliminary design information, together with discussion of the computer code used for mission analyses and trade-off studies in selecting the best-choice OBIGGS. Volume II contains the specifications and prototype development plan for the best choice OBIGGS as well as life cycle cost comparisons of the best choice OBIGGS with other fire protection techniques.

Documentation of the computer programs used to support this contract were provided to the Air force under Boeing Document Number D180-29903-1, "Fighter Aircraft Fuel Tank Inerting Mission Analysis and OBIGGS Design User's Manual," and Boeing Document Number D180-29903-2, "Life Cycle Cost Analysis for Fighter Fuel Tank Explosion Protection System User's Manual."

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1.0 INTRODUCTION

Fuel tank fire protection is incorporated into most military fighter aircraft because of potential fire hazards due to both combat damage and natural causes. Techniques currently in use include explosion suppressant foam, liquid nitrogen (LN2) inerting and Halon fire suppression. The explosion suppressant foam system is a passive system that utilizes a flexible void filler material to prevent explosive overpressures by localizing any in-tank fires. Liquid nitrogen inerting provides fuel tank protection by filling the vapor space above the fuel (ullage) with a nitrogen rich gas that will not support combustion. Foam filler materials have proven effectiveness but are relatively heavy and complicate aircraft fuel tank maintenance procedures. Liqui nitrogen inerting provides an effective, relatively lightweight fire protection system but has a major logistics disadvantage because the storage bottles must be frequently resupplied and only a few air bases have cryogenic nitrogen handling capabilities. Halon is a very effective fire suppressant but also presents logistics problems and is not well suited to full time protection because of the relati ly high cost of the Halon suppressant. The On-Board Inert Gas Generation System (OBIGGS) is similar to the liquid nitrogen inerting system except that the OBIGGS produces the required inert gas during aircraft operation as opposed to filling storage bottles prior to flight. The OBIGGS, exploiting the fact that air in its natural state is mostly nitrogen (79% by volume), further enriches the nitrogen concentration by partially removing the oxygen in the air using an air separation module. The result is a nitrogen rich gas suitable for fuel tank fire protection.

OBIGGS performance and aircraft applications have been the subject of a number of studies and OBIGGS implementation on helicopter type aircraft has begun. The objective of the present series of studies was to investigate the application of an OBIGGS to fighter aircraft with emphasis on the Advanced Tactical Fighter (ATF) airplane.

The first two tasks, which are described in detail in Volume I of this report were to conduct in-depth mission analyses to identify the appropriate OBIGGS design mission and then complete a preliminary design to identify the "best choice" OBIGGS for the design mission. The preliminary design involved many trade-off studies to minimize the overall aircraft penalty. For example, a relatively small air separation module could perform very efficiently if the supply air was carefully conditioned. However, engine bleed air, weight and volume penalties of the ECS equipment required could be prohibitive. The basic task was given the inert gas requirements from the mission analysis task, optimize the OBIGGS for the mission as well as other operational requirements. The trade-off studies included:

- limited relaxation of the full-time inerting requirement
- stored gas versus demand system
- extent of conditioning of supply air versus air separation module performance
- comparison of OBIGGS with other protection systems
- complexity of control system versus OBIGGS sizing
- OBIGGS weight, volume, reliability, maintainability, and airplane and engine penalties
- ground standby and turn around requirements.

The best choice OBIGGS for Advanced Technology Fighter (ATF) airplane application was defined as the stored gas OBIGGS in which inert gas is generated at a nearly constant rate, compressed to a high pressure and stored in bottles for use as required. Both permeable membrane and molecular sieve air separation modules were evaluated. An advanced technology permeable membrane air separation module was the best choice for ATF application.

Once the best choice OBIGGS was selected, life cycle costs were computed, system and component specifications were established and a prototype development plan was written for this best choice OBIGGS. Volume I contains mission analysis and preliminary design information together with a discussion of the computer code used for trade-off studies in selecting the best choice OBIGGS. Volume II contains the specifications and prototype development plan for the best choice OBIGGS as well as life cycle cost comparisons of the best choice OBIGGS with other fire protection techniques.

2.0 LIFE CYCLE COST STUDY

Life cycle costs include all the cost associated with a vehicle or subsystem over its useful lifetime. In this study life cycle costs of the stored gas and demand OBIGGS were compared with those of Halon, liquid nitrogen and explosion suppressant foam systems. Some generalized comments about these systems are appropriate prior to discussing the detailed results. The OBIGGS have distinct logistics advantages for fighter aircraft application but are slightly heavier than the Halon and liquid nitrogen systems; weight penalties are especially significant on fighter aircraft. The lower weight of the Halon and liquid nitrogen systems is offset by material and labor costs since these systems must be resupplied after each mission. Providing Halon and liquid nitrogen at every base, especially forward operating locations requires transportation of materials and establishing storage or manufacturing plants. These facilities could be disabled by combat damage or equipment malfunction. Furthermore, additional recurring of labor costs are involved due to servicing requirements. The explosion suppressant foam has the distinct advantage of being a passive system. However, the foam system is significantly heavier than the others because the weight penalty includes both the weight of the foam and the retained fuel that clings to the foam as the tank is depleted. The explosion suppressant foam was assumed to be an, as yet, undeveloped high temperature foam compatible with the ATF. This foam was assumed to have the same weight and other characteristics as current foam.

The technical breakthrough in air separation module (ASM) technology for OBIGGS applications discussed in Volume I provide large weight savings over current ASMs. Therefore, the OBIGGS in these life cycle cost studies were based on the advanced technology ASMs.

The results of life cycle cost studies provide important guidance with respect to identifying the important cost factors of various systems and identify areas of development needed to reduce costs. However, a ground rule for this study was that the best choice OBIGGS would be the system upon which specifications and the prototype development plan would be based regardless of the results of the life cycle cost studies.

2.1 Life Cycle Cost (LCC) Analysis

The life cycle cost (LCC) analysis included relative research, development, test and evaluation (RDT&E) production and 20 year operating and support (O&S) costs. The analysis provided a tool for determining the cost effectiveness and comparison of various systems. Each subsystem design was sufficient to estimate complexity, reliability, maintainability, weight and volume of line replaceable units (LRUs) for inputs to the cost models.

The RCA Program Review of Information for Costing and Evaluation (PRICE H) for hardware and the Air Force Logistics Command Logistics Support Cost Model Version 1.1 (AFLC/LSC) dated January 1979 were the cost models used. The cost models provided relative LCC estimates based upon comparative analysis of logistics parameters, system performance, physical description, operational concepts and force size. The LCC model considered trade-offs between development and production costs versus the impact of improved maintainability, reliability and survivability on O&S costs (Figure 1).

The PRICE H model computes comparative unit development and production costs and reliability and maintainability factors for each LRU in a system using a parametric approach. This program has been used in the B-1 avionics program, advanced strategic avionics, atmospheric electric hazard program and the all electric airplane program. Specific inputs to the PRICE H model for each LRU include:

- General
  - Production quantity
  - Prototype quantity
  - Weight
  - Volume
- Next higher assembly integration factors
  - Electronic
  - Structural
- Operating environment specification level
- Year of economics
- Mechanical/Structural
  - Structure weight
  - Manufacturing complexity

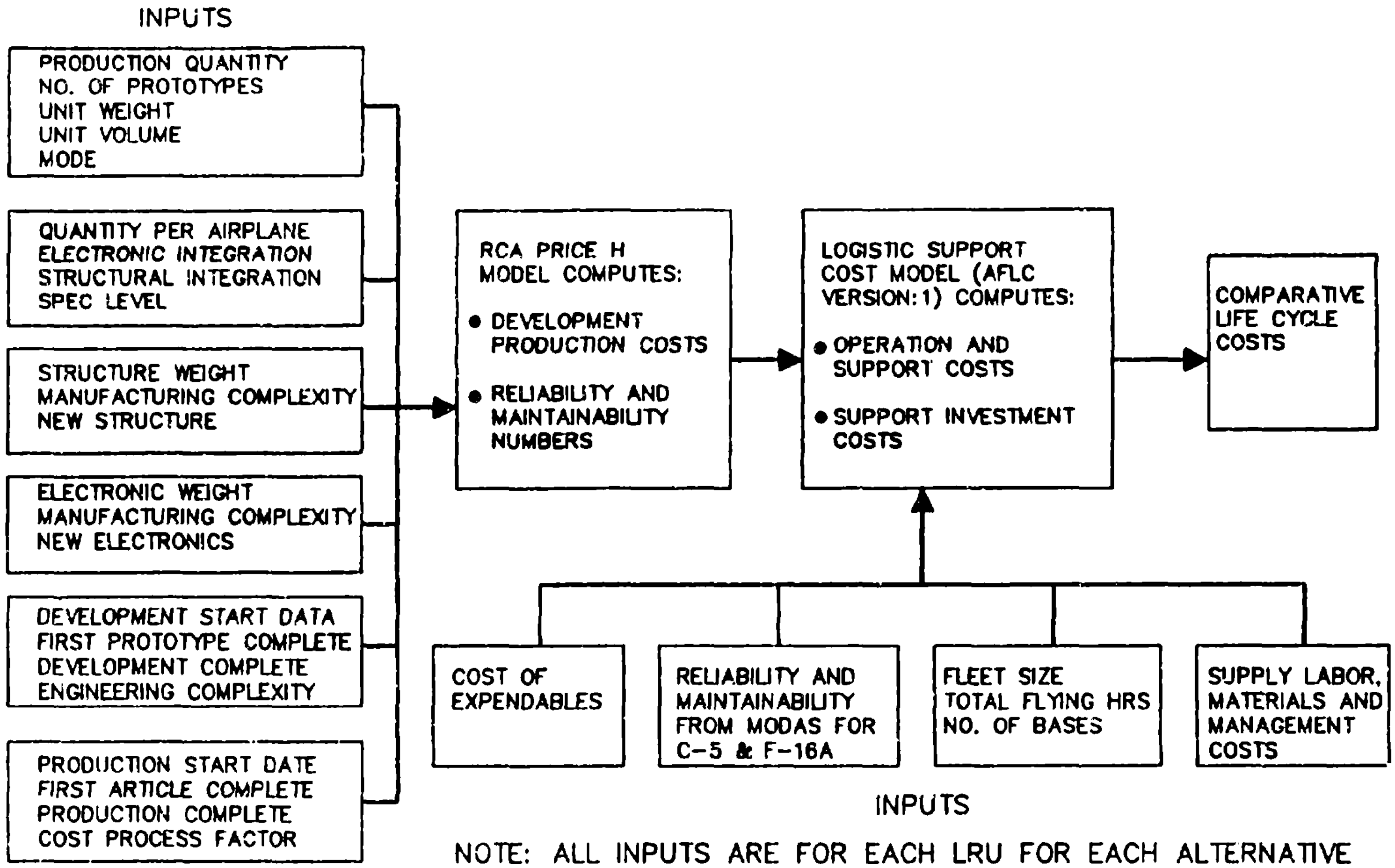

Figure 1. OBIGGS System Trade Study Flow Diagram for Life Cycle Cost

    - Degree of new design for the structure
    - Amount of structural repetition
    - Mechanical reliability
- Electronics
    - Electronic packaging density
    - Manufacturing complexity
    - Degree of new electronic design
    - Amount of electronic repetition
    - Electronic reliability
- Development
    - Start date
    - First prototype date
    - Last prototype date
    - Engineering complexity factor
    - Level of tooling and test equipment
    - Prototype support factor
- Production
    - Start date
    - Date of first completed article
    - End date
    - Price improvement factor

The inputs to the PRICE H model for the five fire protection systems discussed above are listed in Appendix A. The LSC model is a deterministic model using exact formulas to predict operation and support costs (O&S) and support investment costs. The LSC was modified for the current study, the modifications ranged from providing sufficient room for addition of research and development costs to incorporation of the frequency of Retest OK (RTOK).

The following statement, which is quoted from the AFLC LSC Model Version 1.1 Users Handbook was the basis for developing the OBIGGS LCC Model.

> "The LSC Model is a method to estimate the expected support cost that may be incurred by adopting a particular design. The model is used to compare and discriminate among design alternatives where relative cost difference is the desired figure of merit. The significance of the results, therefore, is not based on the absolute value of support costs but on the magnitude of the cost difference between two alternatives. In this regard,

the LSC Model is not, strictly speaking, a life cycle cost model, although it is one of the many specialized models used to support the techniques known as life cycle costing."

The inputs and outputs for the LSC model, including definition of the variables used is presented in Appendix B and Appendix C, respectively.

2.2 Elements of Life Cycle Cost Analysis

2.2.1 Ground Rules and Assumptions

The LCC comparisons are based upon the following assumptions:

(All Costs in 1985 Dollars)

Prototype Hardware	10 units
Prototype Spares	5 units
Qualification Testing	5 units
Production Quantity	750, 1500
Operational Quantity	600, 1200
Flying Hours	300 per year
Operating Period	20 years
Airplanes per Squadron	24
Number of Bases	25
FOAM	$21/cu. ft.
LN_2	$.11/lb.
HALON	$3.03/lb.
Fuel Cost	$.94/gal
Labor cost	$27.67/hr

The operational quantity of 600 aircraft was assumed to be deployed in the United States. However, where significant cost differences between United States and overseas deployment existed, a ratio of 60% United States to 40% foreign deployment was assumed. For example, total costs of servicing liquid nitrogen units and Halon systems was assumed to be somewhat higher at foreign forward operating locations.

2.2.2 Support Equipment and Investment

Support investment costs included initial spares, ground support equipment, technical data, training, and training equipment.

Support equipment costs were added to the Halon and Liquid Nitrogen systems as a Flight Line Servicing Equipment input. The Liquid Nitrogen system required Flight Line servicing in much the same manner as the Fire Suppression System on the C-5A. The Flight Line LN_2 Servicing Tank Truck (GSU), NSN 2320-00-099-9346 at a cost of $106,628.00 with an assumed basis of issue of one (1) per six (6) aircraft was assumed.

The Halon system also required flight line servicing. Representative inputs with the same basis of issue as LN_2 support equipment were made from items listed in the Table of Allowance (TA 316) for the F-16. The selected items included the Compressed Gas Trailer, NSN 3655-00-541-1385, cost $5603.00 and the Halon 1301 Charging Assembly, NSN 4940-01-1C9-8237, cost $5684.57.

Support investment costs were estimated using the LSC model. These costs include support equipment and initial spares that were estimated based upon the support inputs and logistic concepts consistent with a 1990+ time frame.

2.2.3 Research Development Test and Engineering (RDT&E) Costs

The RDT&E cost elements included those efforts required to develop previously undeveloped or partially developed component/systems. The study presupposed that the new technology items identified as requiring further development will have received the required development funding prior to the technology availability date (1989) of this system. Therefore, these costs were not included in RDT&E. Items involved were: (1) the research into what was required, what existed, how it functioned and how it interacted with the system; (2) the design engineering required to select and configure components; and (3) test and evaluation to insure that component performance met the required specifications. Production nonrecurring tooling and test equipment costs were included. The RDT&E costs were evaluated by the PRICE H model and used as inputs to the LSC model.

2.2.4 Production Costs

Production costs were the sum of all costs, recurring and nonrecurring, based on the total anticipated production. Included in the production costs were the system hardware production costs, program management, software and warranty. Hardware production costs were estimated by the PRICE-H model. Initial LRU spares, peculiar support equipment, personnel training, and technical data costs were included in initial support costs. Unit production costs, produced by PRICE-H, were provided as input to the LSC model for each hardware element.

2.2.5 Operating and Support Costs (O&S)

Operating and support costs include those efforts required to operate and maintain the candidate systems throughout their operational life. Maintenance support costs include the effort required to repair, rework, and replace failed parts. The O&S costs were evaluated by the LSC model.

2.2.6 Reliability and Maintainability

The Reliability and Maintainability LSC model inputs were obtained from AFM 66-1 data in the Maintenance and Operational Data Access System (MODAS) for the C-5 and F-16A aircraft.

	SYSTEM	WUC	DATES	TOTAL FLIGHT HOURS
C-5	Nitrogen Inerting	49BXX	Dec 1983 Thru Nov 1985	119381.2
F-16A	Pressure Explosion Suppression	46CXX	Dec 1983 Thru Nov 1985	339655.2

These systems were selected because of the similarity of the components to those proposed for the alternative to OBIGGS. Foam inputs were extracted from similar F-15 experience data and vendor contact. ASM inputs were determined by engineering analysis and vendor contact.

The reliability and maintainability factors for these systems are presented in Tables 1 through 6. Figure 2 contains a description of the headings used on these tables.

Table 1 shows the R&M inputs for those components that are common to all five of the inerting systems. Note that other inputs, such as weight, unit production cost, R&D cost, for these components from unique values for each of the five systems.

Table 2 contains R&M inputs for the demand OBIGGS system. Values for components 8 through 26, were developed using AFM 66-1 (MODAS) data. For components numbered 27 and on, no comparable component was available and the R&M values were determined using output from the PRICE-H model.

Table 3 shows the R&M inputs for the stored gas OBIGGS. Data available from comparable components is used in items numbered 8 through 25 while PRICE-H R&M output parameters are used for items 26 and on.

Tables 4 through 6 show the LSC model R&M inputs for Halon, Liquid Nitrogen, and Foam respectively. Servicing required for replacing the Halon and liquid nitrogen has been accounted for by treating these items as propulsion peculiar inputs and creating a separate system to account for each liquid. This allowed for use of the engine fuel consumption aspect of the model to account for Halon and liquid nitrogen consumption on each flight.

Each fire protection system places a different demand on the ECS system; unique inputs from LRU representing the required ECS support were included for each protection system.

Halon and LN_2 MTBM were calculated without the post flight servicing interval for these cases to eliminate the unrealistic effect of that interval on system MTBM. These system MTBM's are shown below:

STORED GAS	ON-DEMAND	HALON	LN_2	FOAM
149.76	195.62	198.08	163.15	286.31

Table 1 LCC Model Reliability and Maintainability Input Factors - Common Components

	MTBF	RIP	RTS	NRTS	BCOND	DCOND	PAMH	IMH	RHH	BBCMH	DBCMH	BMH	DMH
1 PRECOOLER	3500	.30	.50	.65	0	0	1.5	3.5	7.0	.5	.5	3.0	5.0
2 PRESSURE REGULATOR SHUT-OFF VALVE	2000	.50	.10	.40	0	0	1.5	2.0	3.0	1.0	1.0	2.5	3.0
3 PRIMARY HEATER	5000	.30	.50	.65	0	0	1.5	3.2	6.5	.5	.5	3.0	5.0
4 PRECOOLER TEMPERATURE CONTROL VALVE	7000	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
5 TEMPERATURE SENSOR	20000	.60	0	0	.40	0	1.5	1.5	3.1	0	0	0	0
6 DUCT AND FITTINGS	15000	.40	0	0	.60	0	1.5	3.0	5.0	0	0	0	0
7 WIRE AND MISC.	1000	.90	0	0	.10	0	1.5	2.5	2.0	0	0	0	0

Table 2 LCC Model Reliability and Maintainability Input Factors - On Demand

	MTBF	RIP	RTS	NRTS	BCOND	DCOND	PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH
8 SOLENOID VALVE	8000	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
9 CREW SERVICE HEATER	10000	.30	.05	.65	0	0	1.5	3.5	7.0	.5	.5	3.0	5.0
10 WATER EXTRACTOR	25000	.25	.15	.60	0	0	1.0	2.5	3.2	.5	.5	1.5	2.0
11 PMIGG UNITS	7300	.25	.20	.55	0	0	1.0	3.0	3.5	.5	.5	1.0	3.0
12 DUCT & FITTINGS	75000	.40	0	.10	.60	0	1.5	3.0	5.0	0	0	0	0
13 SOLENOID VALVES HI PRESS	800	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
14 ORIFICE & FITTING	100000	.40	0	0	.60	0	1.5	3.0	5.0	0	0	0	0
15 PRESSURE SENSOR	15000	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
16 FLOW SENSOR	6200	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
17 O_2 SENSOR	2000	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
18 TEMPERATURE SENSOR	20000	.60	0	0	.40	0	1.5	1.5	3.1	0	0	0	0
19 CONTROLLER/BIT	18000	.10	.50	.40	C	0	.5	1.0	1.4	3.0	2.0	5.0	5.0
20 DUCT & FITTING	15000	.40	0	.60	0	0	1.5	3.0	5.0	0	0	0	0
21 SOLENOID VALVE	8000	.05	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
22 ORIFICE & FITTING	75000	.10	0	0	.90	0	1.0	2.0	1.0	0	0	0	0
23 DEMAND REGULATOR	3500	.10	.10	.80	0	0	1.0	3.0	7.0	1.0	1.0	2.5	3.0
24 CLIMB/DIVE VALVE	1000	.10	.10	.80	0	0	4.0	6.0	15.0	1.0	1.0	2.5	3.0
25 SCRUB NOZZLE	100000	.10	.10	.80	0	0	15.0	4.0	5.0	1.0	1.0	2.5	5.0
26 CHECK VALVE	75000	.10	0	0	.90	0	1.0	2.0	1.0	0	0	0	0
27 ECS	1323	.01	.95	.05	0	.01	.50	1.0	.50	.50	.50	500.	5.0

Table 3 LCC Model Reliability and Maintainability Input Factors - Stored Gas

	MTBF	RIP	RTS	NRTS	BCOND	DCOND	PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH
8 SOLENOID VALVE	8000	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
9 CREW SERVICE HEATER	10000	.30	.05	.65	0	0	1.5	3.5	7.0	.5	.5	3.0	5.0
10 WATER EXTRACTOR	25000	.25	.15	.60	0	0	1.0	2.5	3.2	.5	.5	1.5	2.0
11 PMIGG UNITS	7300	.25	.20	.55	0	0	1.0	3.0	3.5	.5	.5	1.0	3.0
12 DUCT & FITTINGS	75000	.40	0	.10	.60	0	1.5	3.0	5.0	0	0	0	0
13 SOLENOID VALVES HI PRESS	800	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
14 ORIFICE & FITTING	100000	.40	0	0	.60	0	1.5	3.0	5.0	0	0	0	0
15 PRESSURE SENSOR	15000	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
16 FLOW SENSOR	6200	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
17 O_2 SENSOR	2000	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
18 TEMPERATURE SENSOR	20000	.60	0	0	.40	0	1.5	1.5	3.1	0	0	0	0
19 CONTROLLER/BIT	18000	.10	.50	.40	0	0	.5	1.0	1.4	3.0	2.0	5.0	5.0
20 DUCT & FITTING	15000	.40	0	.60	0	0	1.5	3.0	5.0	0	0	0	0
21 SOLENOID VALVE	8000	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
22 ORIFICE & FITTING	75000	.10	0	0	.90	0	1.0	2.0	1.0	0	0	0	0
23 DEMAND REGULATOR	3500	.10	.10	.80	0	0	1.0	3.0	7.0	1.0	1.0	2.5	3.0
24 CLIMB/DIVE VALVE	1000	.10	.10	.80	0	0	4.0	6.0	15.0	1.0	1.0	2.5	3.0
25 SCRUB NOZZLE	100000	.10	.10	.80	0	0	15.0	4.0	5.0	1.0	1.0	2.5	5.0
26 CHECK VALVE	75000	.10	0	0	.90	0	1.0	2.0	1.0	0	0	0	0
27 ECS	1357	.01	.95	.05	0	0	.5	1.0	.5	.5	.50	500.	5.0
28 FLOW CONTROL VALVE	9502	.01	.95	.05	0	0	.5	1.0	.5	.5	.50	500.	5.0
29 COMPRESSOR MOTOR, INTERCOLLERS	2251	.01	.95	.05	0	0	.50	1.0	.5	.5	.50	50.	5.0
30 HIGH PRESSURE BOTTLE & FITTINGS	3001	.01	.95	.05	0	0	.50	1.0	.5	.5	.50	500.	5.0
31 HIGH PRESSURE GROUND SERVICE	11065	.01	.95	.05	0	0	.50	1.0	.5	.5	.50	50.	5.0
32 HIGH PRESSURE REGULATOR	6480	.01	.95	.05	0	.01	.50	1.0	.5	.5	.50	50.	5.0
33 SOLENOID SHUTOFF VALVE	8000	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	3.0
34 MANUAL SHUTOFF VALVE	13623	.01	.95	.05	0	0	.50	1.0	.5	.5	.50	50.	5.0
35 CONDENSATION DEM/VALVE	13623	.01	.95	.05	0	0	.50	1.0	.5	.5	.50	500.	5.0
36 CHECK VALVE	19550	.01	.95	.05	0	0	.50	1.0	.5	.5	.50	50.	5.0
37 BOOST COMPRESSOR, EJECTION MOTOR	4388	.01	.95	.05	0	.01	.50	1.0	.5	.5	.50	50.	5.0
38 BOOST COMPRESSOR AFTER COOLER	9807	.01	.95	.05	0	.01	.50	1.0	.5	.5	.50	50.	5.0

Table 4 LCC Model Reliability and Maintainability Input Factors - Halon

	MTBF	RIP	RTS	NRTS	ECOND	DCOND	PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH
8 STORAGE BOTTLES	8000	.50	.05	.45	0	0	1.5	3.0	8.0	0	1.0	2.0	3.0
9 FILL VALVE	100000	.50	.15	.35	0	0	1.0	1.8	7.0	.5	.5	2.5	2.5
10 GROUND SERVICE CONNECTOR	3000	.50	.15	.35	0	0	1.0	4.5	5.0	.5	.5	2.5	2.5
11 SOLENOID SHUT-OFF VALVE	5500	.50	.15	.35	0	0	1.0	4.0	4.2	1.0	1.0	2.5	3.0
12 FILL LINE	100000	.50	0	0	.50	0	1.0	1.8	3.0	0	0	0	0
13 PRESSURE SENSOR	15000	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
14 QUANTITY SENSOR	6500	.50	0	0	.50	0	1.0	2.5	5.0	0	0	0	0
15 RELIEF VALVE	7000	.50	.15	.35	0	0	1.0	4.0	4.0	1.0	.5	2.5	2.5
16 CONTROLLER/BIT	18000	.10	.50	.40	0	0	.5	1.0	1.4	3.0	2.0	5.0	5.0
17 HIGH PRESS REGULATOR	5500	.50	.10	.40	0	0	1.5	2.0	3.0	1.0	1.0	2.5	3.0
18 FLOW CONTROL BLEED AIR VALVE	7000	.50	.10	.40	0	0	1.5	2.0	3.5	1.0	1.0	2.5	4.0
19 BLEED AIR SUPPLY LINE	8000	.05	0	0	.95	0	1.0	3.0	7.0	0	0	0	0
20 ORIFICE & FITTINGS	100000	.40	0	0	.60	0	1.5	3.0	5.0	0	0	0	0
21 DUCT & FITTINGS	75000	.40	0	0	.60	0	1.5	3.0	7.0	1.0	1.0	2.5	3.0
22 DEMAND REGULATOR	3500	.10	.10	.80	0	0	1.5	3.0	7.0	1.0	1.0	2.5	3.0
23 CLIMB/DIVE VALVE	1000	.10	.20	.80	0	0	1.5	6.0	15.0	1.0	1.0	2.5	3.0
24 CHECK VALVE	75000	.10	0	0	.90	0	1.5	2.0	1.0	0	0	0	0
25 HALON	3	1.00	0	0	0	0	.4	1.0	0	0	0	0	0
26 ECS	1363	.01	.95	.05	0	0	0.5	1.0	.50	.50	.50	500	5.0

Table 5 LCC Model Reliability and Maintainability Input Factors - Liquid Nitrogen

	MTBF	RIP	RTS	NRTS	BCOND	DCOND	PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH
8 DEWARDS	2500	.50	.05	.45	0	0	1.5	3.0	8.0	0	1.0	2.0	3.0
9 MANIFOLD	10000	.50	.15	.35	0	0	1.0	4.0	5.0	.5	.5	2.5	2.5
10 REVISE/VENT VALVE	7000	.50	.15	.35	0	0	1.0	4.0	4.0	1.0	1.0	2.5	2.5
11 FILL VALVE	8000	.50	.15	.35	0	0	1.0	6.5	7.0	.5	.5	2.5	2.5
12 SOLENOID SHUT OFF VALVE	5500	.50	.15	.35	0	0	1.0	4.0	4.2	1.0	1.0	2.5	3.0
13 GROUND SERVICE VALVE	3000	.50	.15	.35	0	0	1.0	4.5	5.0	.5	.5	2.5	2.5
14 FILL LINE	100000	.50	0	0	.50	0	1.0	1.8	3.0	0	0	0	0
15 QUANTITY SENSOR	6500	.50	0	0	.50	0	1.0	2.5	5.0	0	0	0	0
16 PRESSURE SENSOR	15000	.50	0	0	.50	0	1.0	1.5	2.1	0	0	0	0
17 CONTROLLER/BIT	18000	.10	.50	.40	0	0	.5	1.0	1.4	3.0	2.0	5.0	5.0
18 MANIFOLD & LINES	1000	.05	.10	0	.95	0	1.0	3.0	7.0	0	0	0	0
19 DEMAND REGULATOR	3500	.10	.10	.80	0	0	1.0	3.0	7.0	1.0	1.0	2.5	3.0
20 SCRUBBER HEATER	20000	.10	.10	.80	0	0	15.0	4.0	9.0	1.0	1.0	2.5	5.0
21 SOLENOID VALVE	3000	.50	0	0	.40	1.5	2.0	3.5	1.0	1.0	2.5	2.5	3.0
22 ORIFICE & FITTINGS	75000	.10	.10	0	.90	0	1.0	2.0	1.0	0	0	0	0
23 CLIMB/DIVE VALVE	1000	.10	.10	.80	0	0	4.0	6.0	15.0	1.0	1.0	2.5	3.0
24 SCRUBBER NOZZLE	100000	.10	0	.80	0	0	15.0	4.0	5.0	1.0	1.0	2.5	5.0
25 CHECK VALVE	75000	.10	0	0	.90	0	1.0	2.0	1.0	0	0	0	0
26 LN_2	3	1.00	0	0	0	0	.5	1.0	0	0	0	0	0
27 ECS	1363	.01	.95	.05	0	0	0.5	1.0	.50	.50	.50	500	5.0

Table 6 LCC Model Reliability and Maintainability Input Factors - Foam

	MTBF	RIP	RTS	NRTS	BCOND	DCOND	PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH
8 ECS	1362	.01	.95	.05	0	0	0.5	1.0	.50	.50	.50	500	5.0
9 ORIFICE & FITTINGS	75000	.10	0	0	.90	0	1.0	2.0	1.0	0	0	0	0
10 WIRING & MISC.	15000	.90	0	0	.10	0	1.0	2.5	2.0	0	0	0	0
11 DEMAND REGULATOR	3500	.10	.10	.80	0	0	1.0	3.0	7.0	1.0	1.0	2.5	3.0
12 CLIMB/DIVE VALVE	1000	.10	.10	.80	0	0	4.0	6.0	15.0	1.0	1.0	2.5	3.0
13 CHECK VALVE	7500	.10	0	0	.90	0	1.0	2.0	1.0	0	0	0	0
14 FOAM	43800	0	0	100	0	1.0	500.0	0.0	100.0	0	0	0	0

AVERAGE MAN HOURS FOR REPAIR

IMH	Repair in-place with out removal-includes fault isolation repair & verification
RMH	Fault isolate, remove, replace and verify on aircraft
PAMH	Prepare aircraft for repair, i.e. jacking, panels, remove to access, hookup to support equipment
BBCMH	Shop bench check, screening, & fault verification
BMH	Shop repair, fault isolation, repair, verification
DBCMH	Depot bench check, screening & fault verification
DMH	Depot repair, fault isolation, repair, verification

REPAIR LOCATION (FRACTIONS)

RIP	Repair in place without removal
RTS	Repair at base level
BCOND	Condemnation at base level
NRTS	Returned to Depot
DCOND	Condemnation at Depot level/fraction sent to Depot
MTBF	Mean time between maintenance in operating hours of the LRU in the operating environment

Figure 2 Explanation of R&M Input Table Headings

2.2.7 Fuel Penalties

Fuel penalties for power and bleed air extraction and for the additional weight were considered for a constant range mission. Only bleed flow penalties beyond that for normal fuel tank pressurization was considered. In order to fly a consistant range mission the generic ATF with an inerting system onboard must carry more fuel and grow in size (large tanks, larger engines, etc.). For the generic ATF the sensitivity factor for the increase in aircraft weight per pound of added equipment was about six. Since about half the weight increase is for additional fuel, three pounds of additional fuel was required per pound of added system weight in this study. The total fuel penalties are shown in Table 7. The bleed, ram and power extractions for the demand OBIGGS were less than the stored gas OBIGGS because the system was shut-off when repressurization gas was not required, where the stored gas ran continuously.

Table 7 Fuel Penalties for Generic ATF Constant Range (pounds of fuel)

Inerting System	Bleed	Ram	Compressor Power	ECS Power	System Weight	Total lbs.
Stored Gas OBIGGS	8.8	15.5	5.8	3.5	774	808
Demand OBIGGS	10.9	11.3	0	.75	1095	1118
LN_2	0	0	0	0	233	699
Foam	0	0	0	0	2202	2202
Halon	0	0	0	0	504	504

Because of the sensitivity factor, heavier systems suffer from a fuel penalty point of view. The fuel penalty for the foam system includes the weight of retained fuel.

2.3 Results of the LCC Analysis

The life cycle cost comparisons are shown in Tables 8 and 9 and Figure 3. Fuel penalties due to equipment weight were by far the largest cost factor based upon and average mission of 1.78 hours. The foam system had the largest fuel penalty due to its relatively high weight. Therefore, even though the foam system had the lowest life cycle cost without the fuel penalty, adding the fuel penalty caused the total life cycle cost of the foam system to be the highest. The Halon system had the lowest weight penalty but the cost of Halon caused this system to have relatively high life cycle costs. The costs of the OBIGGS and liquid nitrogen system were similar but the OBIGGS had the lowest overall costs. The key factors here were the cost of supplying liquid nitrogen to overseas bases and forward operating based and the manhours required to service the liquid nitrogen system after each flight.

Table 8 Life Cycle Cost Summary (750 Production)
Million of 1985 Dollars

Cost Categories	OBIGGS Stored Gas	OBIGGS On-Demand	Halon	LN_2	Foam
Development	$ 15.0	$ 14.9	$ 11.6	$ 12.4	$ 9.6
Procurement					
Production	160.8	150.7	120.5	122.3	106.5
Support Investment	13.6	12.7	12.2	22.1	10.4
Subtotal	174.4	163.4	132.7	144.4	116.9
Operating and support (20-years)	107.4	55.8	528.2	213.9	53.8
Fuel Penalty	236	327	147	204.5	644
Total LCC	532.8	561.1	819.4	575.3	824.3

Table 9 Life Cycle Cost Summary (1,500 Production)
Millions of 1985 Dollars

Cost Categories	OBIGGS Stored Gas	OBIGGS On-Demand	Halon	LN_2	Foam
Development	$ 15.0	$ 14.9	$ 11.6	$ 12.4	$ 9.6
Procurement					
Production	295.9	277.2	221.6	224.9	195.9
Support Investment	22.0	20.4	7.3	39.3	16.2
Subtotal	317.9	297.6	241.2	264.3	212.1
Operating and support (20-years)	213.8	110.6	1055.6	406.6	106.9
Fuel Penalty	472	654	294	409.0	1288
Total LCC	1018.7	1077.1	1602.4	1081.9	1616.6

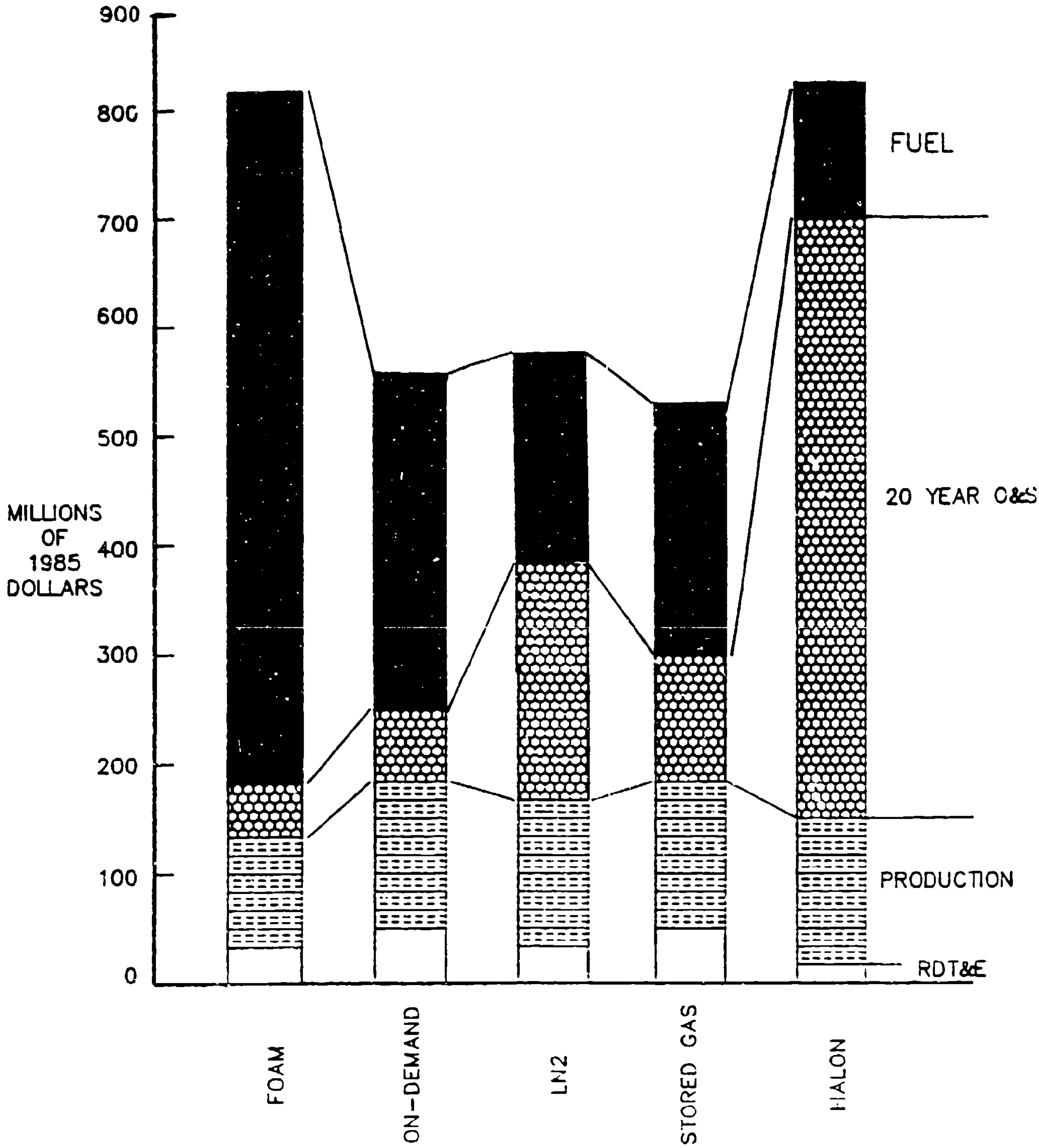

Figure 3. Life Cycle Cost Comparison

3.0 OBIGGS SPECIFICATIONS

The system specification for the best choice stored gas OBIGGS is presented herein in accordance with MIL-STD-490 and DI-CMAN-80008. The system is based on the requirements for a generic advanced tactical fighter and, as such, some TBDs (To Be Determined) were required in the specification process.

Basically, the OBIGGS creates NEA by partially separating oxygen and nitrogen by supplying an air separation module with properly conditioned engine bleed air. In a stored gas OBIGGS, NEA is compressed and metered to the fuel tank as required using control valves and pressure regulators.

NEA is required throughout the aircraft mission to scrub dissolved oxygen from the fuel during taxi and climb out, to provide makeup gas for fuel depletion during cruise to repressurize fuel tanks during descent. In all these processes the key to fire protection is to ensure that the oxygen concentration in the ullage does not exceed 9% by volume.

3.1 Applicable Documents

All documents and standards contained herein are listed in numeric order.

3.1.1 Government Documents

The following documents of the issue shown form a part of this specification to the extent specified herein.

3.1.1.1 Federal Specifications and Standards

PPP-P-636H (1)	08 Apr 77	Box Shipping Fiberboard
PPP-C-1752A (1)	18 Jun 75	Cushioning Material, Packaging Unicellular Polyethlene Foam, Flexible

PPP-B-6101F (2)	06 Sep 77	Boxed Wood Cleated Plywood
FED-STD-102B	29 Jan 63	Preservation, Packaging and Packing Levels

3.1.1.2 Military Specifications

MIL-S-4040D (1)	02 Feb 71	Solenoid, Electrical, General Specification for
MIL-S-5002C (1)	28 Aug 78	Surfaces Treatments and Inorganic Coatings for Metal Surfaces of Weapons
MIL-E-5007D (2)	08 Oct 82	Engine, Aircraft, Turbojet, and Turbofan, General Specification for
MIL-B-5087B (2)	31 Aug 70	Bonding, Electrical and Lighting Protection for Aerospace Systems
MIL-C-5501F (1)	01 Oct 75	Caps and Plugs, Protective Dust and Moisture Seal, General Specification for
MIL-P-5518C (1)	03 Dec 68	Pneumatic Systems, Aircraft, Design, Installation, and Data Requirements for

MIL-C-5541C	14 Apr 81	Chemical Film for Aluminum and Aluminum Alloys
MIL-C-6021H (1)	08 Jul 83	Castings, Classification and Inspection of
MIL-E-6051D (1)	05 Jul 68	Electromagnetic Compatibility Requirements, Systems
MIL-H-6088F (1)	30 Dec 82	Heat Treatment of Aluminum Alloys
MIL-W-6858D	28 Mar 78	Welding, Resistance, Spot and Seam
MIL-W-6873B	06 Sep 78	Welding, Flash, Carbon and Alloy Steel
MIL-H-6875G	16 Sep 83	Heat Treatment of Steels (Aerospace Practice, Process for)
MIL-P-6906B (1)	09 Nov 73	Plates, Identification, Aircraft
MIL-P-7105B (1)	08 Aug 66	Pipe Threads, Taper, Aeronautical National Form, Symbol NPT, General Requirements

MIL-F-7179F (1)	25 Sep 84	Finishes, Coatings, and Sealants for the Protection of Aerospace Weapons Systems
MIL-P-7788E (1)	16 Apr 69	Panel, Information, Integrally Illuminated
MIL-B-7883B	20 Feb 68	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys
MIL-C-7905 (42)	03 Aug 84	Cylinders, Compressed Gas, Non-Shatterable
MIL-A-8421F	25 Oct 74	Air Transportability Requirements, General Specifications for
MIL-I-8500D	25 Mar 80	Interchangeability and Replaceability of Component Parts for Aerospace Vehicles
MIL-P-8564D	18 Nov 70	Pneumatic System Components, Aeronautical, General Specification for
MIL-E-8593A	15 Oct 75	Engines, Aircraft, Turboshaft and Turboprop, General Specification for

MIL-W-8604A	15 Mar 59	Welding, Fusion, Aluminum Alloys, Process and Performance of
MIL-W-8611A	24 Jul 57	Welding, Metal Arc and Gas, Steels and Corrosion and Heat Resistant Alloys, Process for
MIL-A-8625C	13 Mar 69	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-A-8806B	21 Sep 70	Acoustical Noise Levels in Aircraft, General Specification for
MIL-S-8879A (1)	15 Mar 73	Screw Threads, Controlled Radius Root with Increased Minor Diameter
MIL-Q-9858A (1)	07 Aug 81	Quality Program Requirements
MIL-P-15024D (1)	10 Aug 82	Plates, Tags and Bands for Identification of Equipment
MIL-F-18264D (1)	23 Apr 71	Finishes: Organic, Weapons System, Application and Control of

MIL-W-22759D (1B)	27 May 80	Wire, Electric, Fluoropolymer Insulated, Copper or Copper Alloy
MIL-A-25363D (2)	08 Feb 83	Accumulator, Pneumatic, Aircraft, Glass Fiber
MIL-W-27076 (1)	19 Jan 76	Workmanship Standards for Ground Equipment and Associated Equipment
MIL-E-38453A	02 Dec 71	Environmental Control, Environmental Protection, and Engine Bleed Air Systems, Aircraft, General Specification for
MIL-I-45208A (1)	24 Jan 81	Inspection System Requirements
MIL-H-46855B (2)	23 Mar 81	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-C-81044B	23 Mar 81	Crosslinked Alkane-Imide Polymer or Polyarylene Insulated Copper, or Copper Alloy

MIL-B-81365	04 Apr 66	Bleed Air Systems, General Specification for
MIL-W-81381A (1B)	04 Jan 82	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
MIL-C-81706 (5)	13 Nov 79	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
MIL-A-83116A	31 Mar 71	Air Conditioning Subsystems, Air-Cycle Aircraft and Aircraft-Launched Missiles, General Specification for
MIL-C-83286B (2)	19 Aug 80	Coatings, Urethane, Aliphatic, Isocyanate, for Aerospace Applications
MIL-C-83723D	27 Dec 77	Connector Electrical, Circular, (Environment Resisting) Receptacles and Plugs, General Specification for

3.1.1.3 Military Standards

MIL-STD-129H (4)	30 Sep 82	Marking for Shipment and Storage
MIL-STD-130F (1)	02 Jul 84	Identification Marking of U.S. Military Property
MIL-STD-143B	12 Nov 69	Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-202F (5)	28 Mar 84	Test Methods for Electronic and Electrical Component Parts
MIL-STD-210B	15 Dec 73	Climatic Extremes for Military Equipment
MIL-STD-454H (3)	30 Aug 83	Standard General Requirements for Electronic Equipment
MIL-STD-461B	01 Apr 80	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462 (4)	01 Apr 80	Electromagnetic Interference Characteristics, Measurement of

MIL-STD-470A	03 Jan 83	Maintainability Program Requirements (for Systems and Equipment)
MIL-STD-471A	08 Dec 78	Maintainability Verification/ Demonstration/Evaluation
MIL-STD-483 (2)	21 Mar 79	Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs
MIL-STD-704D	30 Sep 80	Aircraft Electric Power Characteristics
MIL-STD-721	12 Jun 81	Definitions of Terms for Reliability, Maintainability, Human Factors, and Safety
MIL-STD-785B	15 Sep 80	Reliability Program for Systems and Equipment Development and Production
MIL-STD-810C	10 Mar 75	Environmental Test Methods and Engineering Guidelines
MIL-STD-838C	30 Dec 83	Lubrication of Military Equipment

MIL-STD-850B	03 Nov 70	Aircrew Station Vision Requirements for Military Aircraft
MIL-STD-882B	30 Mar 84	System Safety Program Requirements
MIL-STD-889B (1)	21 Nov 79	Dissimilar Metals
MIL-STD-1188A (1)	31 Jan 84	Commercial Packaging of Supplies and Equipment
MIL-STD-1247B	20 Dec 68	Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missile, and Space Systems
MIL-STD-1388-1A	11 Apr 83	Logistic Support Analysis
MIL-STD-1472C (2)	10 May 84	Military Systems, Equipment, and Facilities
MIL-STD-1523A	01 Feb 84	Age Control of Age-Sensitive Elastomeric Material (for Aerospace Applications)
MIL-STD-45662 (2)	16 May 84	Calibration System Requirements

MS33540H	30 Oct 82	Safety Wiring and Cotter Pinning, General Practices for
MS33588D	30 Nov 73	Nuts, Self-Locking, Aircraft, Design and Usage; Limitations of
MS90376C	19 Apr 78	Caps, Dust, Plastic, Electric Connector

3.1.1.4 Other Publications

ADS 13B	Oct 80	Air Vehicle Materials, Processes and Parts
AFR 161-35	09 Apr 82	Hazardous Noise Exposure
AFR 300-10	15 Dec 76	Computer Programming Languages
AFR DH-1-3	01 Jan 77	Human Factors Engineering
AFR DH-1-6	02 Dec 78	System Safety
AR 70-38	05 May 69	Research, Development, Test and Evaluation of Material for Extreme Climate Conditions
ARP 699C	Aug 66	High Temperature Pneumatic Duct Systems for Aircraft

HHI 82-10	24 Mar 82	Procurement Specification for the Production Nitrogen Inerting Unit, Fuel Tank; (Hughes Helicopter, Inc.)
NAVMAT P-9492	May 79	Navy Manufacturing Screening (Temperature Cycling, Random Vibration)

3.2 Requirements

The stored gas Onboard Inert Gas Generation System (OBIGGS) is required to prevent airplane fuel tank fires and explosions due to both natural and combats threats. The system shall provide full-time fire protection for all ground and flight conditions.

Specifically, the OBIGGS shall provide fuel tank fire and explosion protection for the following conditions:

- o Aircraft operation from taxi to landing including 48-hour ground alert status;
- o Arcing in the fuel tanks due to lightning or electrostatic discharges;
- o Fast turn-around operations;
- o Air-to-air and air-to-ground missions;
- o Subsonic, transonic, and sustained supersonic flights;
- o Ferry missions, and combat missions with multiple climb/dive maneuvers;
- o Operation in a Nuclear/Biological/Chemical (NBC) environment;
- o Operation in all weather and environmental conditions.

The OBIGGS equipment shall be compatible with aircraft operation for world-wide deployment in the climate extremes described in MIL-STD-210B. This will be accomplished by: 1) maintaining an inert gas vapor space or ullage in the fuel tanks and vent lines and 2) providing a gas source for fuel tank pressurization. An inert gas vapor space is obtained by maintaining the oxygen concentration below 9% by volume at all times.

The OBIGGS shall provide Nitrogen Enriched Air (NEA) to the fuel tanks: 1) for scrubbing dissolved oxygen out of the fuel during taxi and the initial aircraft climb-out, and during aerial refueling maneuvers, and 2) to maintain the fuel tank pressurization schedule controlled by the fuel tank vent system's climb/dive valves and demand regulators. The OBIGGS shall have the capability to operate fully automatically, even with the aircraft unattended and no aircraft or ground power. The OBIGGS shall also be compatible with the design, operation, and maintenance of the aircraft's Environmental Control System (ECS) and fuel system.

The OBIGGS shall extract its supply air from the aircraft ECS and reject its waste heat (from its various compressors and heat exchangers) to the aircraft Thermal Management System (TMS). Inert product gas from the Air Separation Module (ASM) shall be stored in high pressure storage bottles, at a maximum pressure of 3000 psig, to minimize storage volume requirements.

The OBIGGS shall also have the capability to:

- o Prevent contaminants (including water and particulate debris larger than 0.6 micron) from reaching the ASM;

- o Account for transient behavior of the ASM and other major system components (i.e., NEA with varying oxygen concentration from the ASM continuously mixing with NEA of a different quality already in the high pressure storage bottle, or NEA oxygen concentration variation which will occur in long distribution ducts or ASM inlet temperature transients or pressure from the TMS);

- o Deliver the specified performance in sustained aircraft compartment temperature extremes of 0° F to 180° F;

- Prevent pneumatic surging resulting in non-steady pressure or flow conditions;

- Maintain the fuel tank ullage oxygen concentration below the 9% oxygen limit for JP-4, JP-5, JP-8, and Jet A aviation fuels, assuming that the aircraft is fueled with 100% air saturated fuel;

- Provide the required quantity of NEA to the fuel tanks to maintain a tank pressure of TBD psig.

- Utilize Built-In Test (BIT) hardware and software to facilitate system maintenance by performing system problem diagnostics through quick fault detection/isolation;

- Operate uninterrupted and provide the specified performance for 30 sec in a sustained aircraft acceleration of -1 g and for 60 sec in a sustained 0 g environment;

- Operate while the aircraft is on the ground by using the aircraft engines, APU, or a standard ground cart to operate the ECS and electrical system;

- Utilize flight-worthy oxygen sensors, pressure transducers, and thermocouples to provide data for system control, status, and maintenance;

- Utilize insulation, thermal blankets or equivalent to ensure system performance and operation does not degrade at environmental temperature extremes (-65^{o} F to +180^{o} F);

- Operate during a 10 minute pressure ground or aerial refueling with a single-point fueling adpater;

- Operate during a 15 minute hot combat turn-around (refuel and reload weapons with engines on or off):

- Operate 30 days of operation without additional airlift support (i.e., autonomous operation during sustained combat);

- o Operate with aircraft climb and descent rates of 20,000 and 100,000 feet per minute respectively.

The OBIGGS shall satisfy all of the above requirements during or after exposure to any or all of the environmental conditions described herein.

3.2.1 System Definition

The OBIGGS inert gas production and storage equipment shall provide a source of clean, dry NEA to the fuel tanks using the inert gas delivery hardware, while minimizing the total aircraft performance penalty.

3.2.1.1 Missions

The OBIGGS shall be capable of supporting Air Force offensive counterair (OCA), and escort of fighter bombers as well as Naval fleet defense missions. Provisions shall be made to maintain fuel tank inerting during a 48 hour ground standby. These provisions include scrubbing the fuel prior to parking the aircraft and resupplying inert gas as required to account for thermal expansion and contraction of the fuel.

3.2.1.2 Threats

The OE 3S shall provide fire protection from in-tank arcing due to lightning strikes and electrostatic discharges and combat threats up to 23 mm HEI.

3.2.1.3 System Modes and States

3.2.1.3.1 Continuous NEA Production

The A' nd , pressure compressor shall operate continuously during the entire mission profile. NEA shall be produced at a constant mass flow rate of 0.65 pound per minute with a maximum oxygen concentration of 5% by volume.

3.2.1.3.1.1 Re surization Gas

The storage bottles and piping shall be sized to provide a maximum flow rate of 36 pounds per minute.

3.2.1.3.1.2 Fuel Scrubbing

NEA from the high pressure storage bottles shall introduced to the bottom of the fuel tanks, at a rate of 2.1 pounds per minute for 10 minutes during ground operations and the initial climbout.

3.2.1.3.2 Failure Modes

3.2.1.3.2.1 High Pressure System Failure

In the event that the output from the high pressure storage bottles ceases during times of required flow, the product gas of the IGG shall flow directly and continuously into the ullage repressurization system, by-passing the high presure compressor and high pressure storage bottle(s).

3.2.1.3.2.2 Maintaining Minimum Positive Tank Pressure

In the event that a rupture in the repressurization system prevents maintaining the minimum positive tank pressures during level flight or descents the scrub mode shall be initiated and continued at a flow rate of TBD pounds per minute until the NEA supply is exhausted. After the NEA supply in the high pressure system is exhausted, the operating mode will be identical to a high pressure system failure.

3.2.1.4 System Functions

The OBIGGS shall accomplish the following functions:

- o Control the temperature, pressure, and moisture of the regulated supply air from the bleed system;
- o Separate oxygen from conditioned bleed air to produce and store nitrogen enriched air;
- o Distribute NEA to required locations in regulated volumes.

3.2.1.4.1 OBIGGS Supply Air Conditioning

The conditioning system shall provide peak supply airflow rates of 4.5 pounds per minute to the ASM at a nominal and minimum pressure of 60 psig and 45 psig and at a nominal and maximum temperature of 95° F and 110° F, respectively, at aircraft altitudes of 0 to 70,000 feet.

3.2.1.4.2 OBIGGS Air Separation and Storage System

The inert gas production and storage portion of the OBIGGS shall provide clean, dry NEA to the fuel tanks using the inert gas distribution system while minimizing the airplane performance penalty. The inert gas system shall satisfy the requirements during and after, exposure to any and all of the environmental conditions described herein.

The design of the inert gas production and storage portion of the OBIGGS shall be driven by the: 1) performance requirements of the ASM and the OBIGGS's high pressure (HP) compressor, 2) penalties to the aircraft from the ASM, HP compressor, and HP bottles (i.e., weight, volume, bleed air, and power), 3) overall control approach implemented to control system performance, and 4) NEA requirements from the inert gas delivery portion of the OBIGGS to the fuel tanks.

3.2.1.4.3 OBIGGS NEA Distribution

The design of the inert gas distribution system portion of the OBIGGS shall be driven by the: 1) fuel tank inerting and repressurization flow requirements, 2) performance requirements for the HP bottles, and 3) the fuel tank vent system design.

The OBIGGS shall be used in conjunction with a closed fuel vent system including climb and dive valves for overpressure and under pressure protection. The inert gas distribution system shall not interfere with fuel tank pressurization and ground/aerial refueling equipment and procedures. The inert gas delivery system shall be designed fail-safe such that a failure will not damage the aircraft. The aircraft's climb and dive valves shall always be operational to this end. The delivery system shall induce turbulent mixing of ullage gas to ensure a uniform NEA concentration gradient throughout the fuel tanks.

Leakage of inert gas (NEA) from the distribution system during flight and non-flight conditions shall be kept to a minimum to ensure the OBIGGS can maintain an inert status in the fuel tanks and reduce aircraft vulnerability during combat missions, ground attacks, and lightning strikes.

The inert gas delivery system shall consist of the low and high pressure inert gas distribution systems, demand regulators, fuel scrubbing hardware, and the fuel tank vent system.

3.2.1.5 System Functional Relationships

The air or NEA throughput is serial through and between all the system functions as shown in Figure 4. The physical interfaces between each system function is mainly the air ducting and the data link to the aircraft data bus for control.

3.2.1.6 Configuration Allocation

The following paragraphs describe and specify the hardware components for the OBIGGS. Schematic diagrams are presented in Figures 5 and 6.

3.2.1.6.1 Boost Compressor

3.2.1.6.1.1 Duty Cycle and Control

The boost compressor shall maintain an adequate supply air pressure of 60 psig to the ASM during the low engine power setting conditions, when the OBIGGS bleed air manifold duct pressures are low. Thus, the ASM shall not suffer any performance degradation during idle descent aircraft maneuvers or airplane taxi. The boost compressor shall not be used during high engine power setting conditions when the OBIGGS bleed air manifold duct pressures are high. The boost compressor shall turn on at 45 psig and shut off at a maximum inlet pressure of TBD. Automatic shut-off in the event of a failure or malfunction shall be provided.

3.2.1.6.1.2 Air Source

The boost compressor shall operate on conditioned engine bleed air with contaminant limits specified in MIL-E-5007D(2), MIL-E-8593A, paragraph

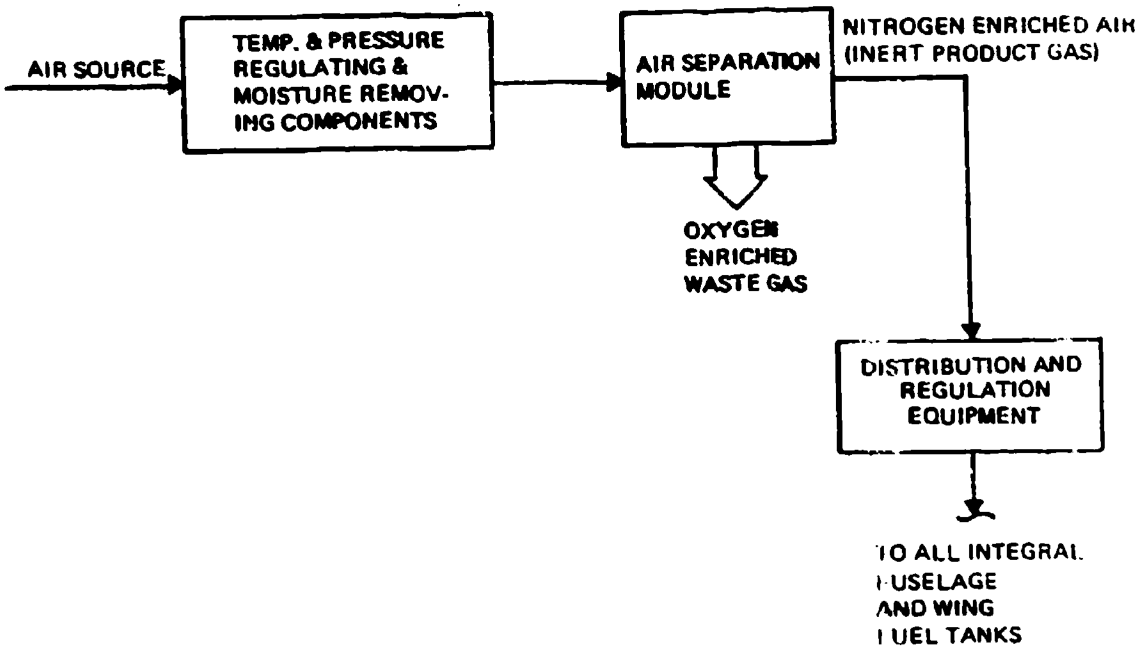

Figure 4. OBIGGS Functional Diagram

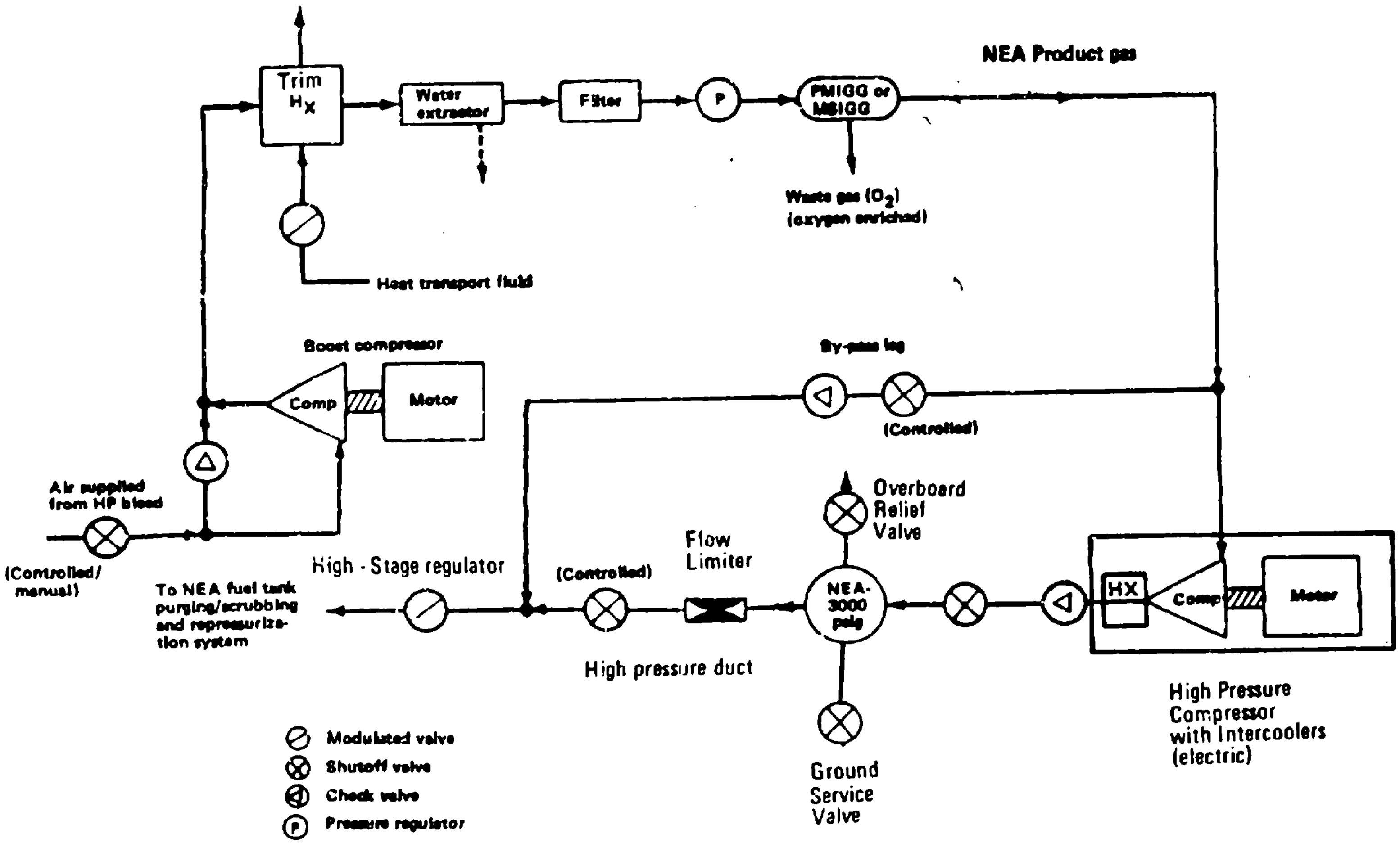

Figure 5. OBIGGS Schematic

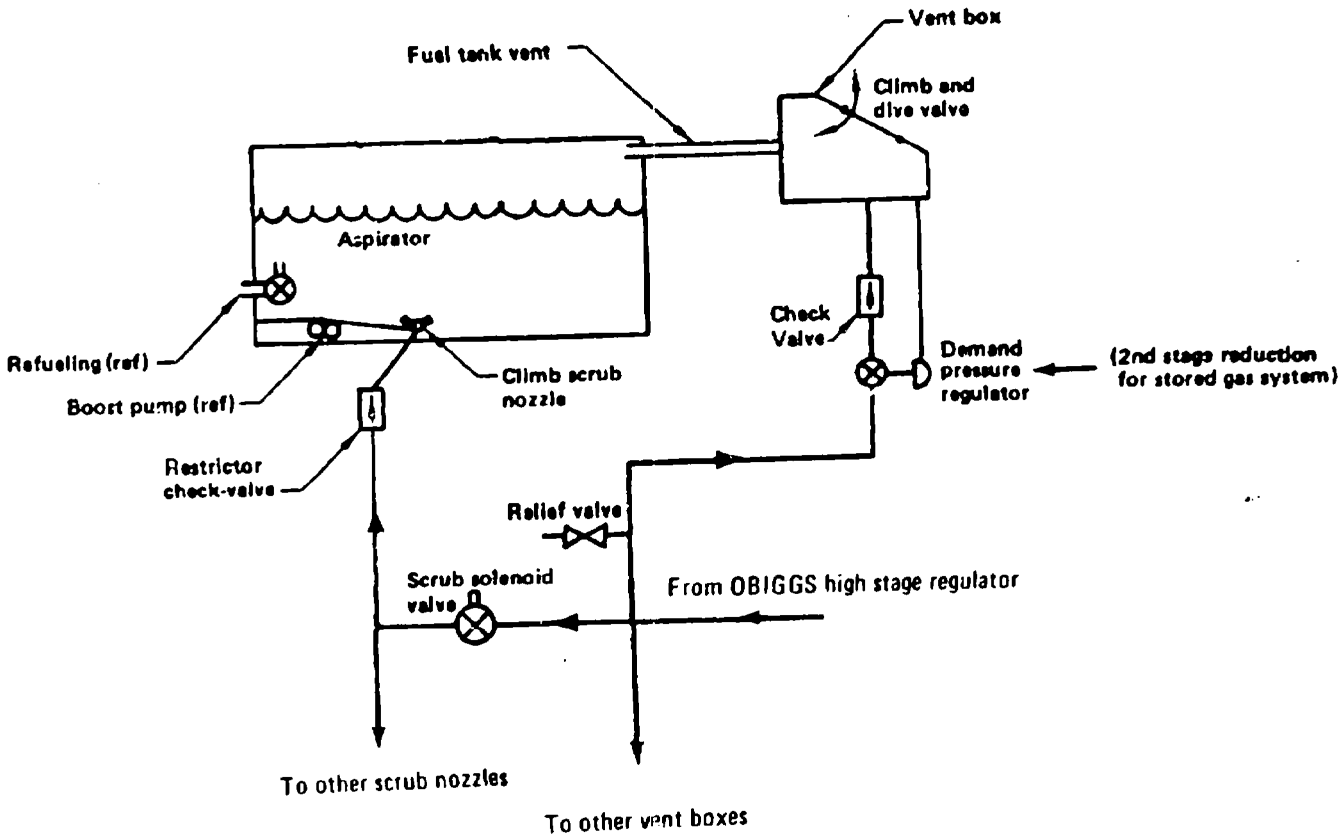

Figure 6. OBIGGS Inert Gas Distribution System

3.1.2.11.3, MIL-E-38453A, MIL-B-81365, and in MIL-A-83116A with negligible performance degradation throughout its design life. This air shall also be Chemical/Biological (CB) filtered, if flow from the common bleed air manifold duct is used for both the Onboard Oxygen Generating System (OBOGS) and the OBIGGS. The bleed air shall be provided at a pre-regulated pressure of no greater than 65 psig and a pre-cooled to a temperature of 95° F. The boost compressor shall not use more than 4.5 lb/min (approximately 59 scfm; 60° F, 1 atm) of bleed air from the OBOGS/OBIGGS bleed air manifold duct. However, as an objective, the boost compressor will only use 3.5 lb/min (approximately 46 scfm; 60° F, 1 atm) of flow.

3.2.1.6.1.3 Performance, Operation, and Characteristics

The boost compressor shall have a minimum outlet-to-inlet pressure ratio of 2:1 with a maximum allowable outlet temperature of 300° F. However, as an objective, this outlet temperature shall only be 270° F. The compressed outlet air shall be clean, and have a maximum allowable compressor lubrication oil contamination of TBD ppm.

The compressor shall:

- o Have a MTBF of 2251 hours;
- o Have power requirements not to exceed 3.0 kW at either 28 VDC, or 115 VAC (400 Hz), or 270 VDC aircraft electrical power;
- o Be packaged and designed to operate with an electric motor;
- o Not weigh more than TBD pounds (including its electric motor), with a weight of TBD pounds (including its electric motor) as an objective;

3.2.1.6.1.4 Monitoring

The supply air pressure and temperature upstream and downstream of the boost compressor shall be monitored, as well as either the compressor's electric motor temperature or electrical current level. These parameters shall provide data for both system operation and BIT functions. The boost compressor shall automatically shut itself off if its outlet air temperature exceeds 300° F or its electrical current level drops below TBD amps.

3.2.1.6.1.5 Indication

Warning shall be provided to the pilot upon BIT detection of an excessively high compressor outlet temperature (> 300^{o} F) or a low electrical current level (< TBD amps), or low compression outlet pressure (< 45 psig).

3.2.1.6.2 Trim Heat Exchanger

3.2.1.6.2.1 Duty Cycle

The trim heat exchanger shall be designed to maintain a supply air temperature of 95^{o} F to the ASM during all aircraft flight modes. The maximum temperature shall not exceed 110^{o} F.

3.2.1.6.2.2 Hot-Side and Cold-Side Fluid Characteristics

The trim heat exchanger shall be designed for air-to-liquid heat transfer for the given cold-side fluid (i.e., Coolanol-25). The hot-side fluid is air from the OBOGS/OBIGGS bleed air manifold duct, which either flows thru or bypasses the ASM supply air boost compressor.

The maximum allowable hot-side inlet air temperature shall be no higher than 300^{o} F while that of the cold-side no higher than 110^{o} F. However, as an objective, the cold-side inlet fluid temperature shall be 80^{o} F. The maximum allowable outlet air temperature shall be no higher than 110^{o} F, however the objective is a temperature of 95^{o} F.

The nominal hot-side supply air pressure will be 60 to 80 psia. The heat exchanger shall be designed for a proof and burst pressure of 200% and 400% of the nominal hot-side supply air pressure respectively. The maximum allowable hot-side supply air pressure drop shall be no higher than TBD psid. The number of passes in the air side and in the liquid side shall not be restricted. The cold-side fluid flowrate shall be no higher than TBD lb/min.

3.2.1.6.2.3 Characteristics

The trim heat exchanger shall have an MTBF of no less than 100,000 hours, and weigh no more than TBD pounds, with a weight of TBD lb as an objective. The unit shall have provisions for a self-cleaning drain port to dump condensed liquid water overboard the aircraft.

3.2.1.6.3 Water Extractor

The water extractor shall be of a centrifugal, swirler type, with a minimum entrained water removal efficiency of 95%. The unit shall weigh no more than TBD pounds and have a minimum MTBF of 50,000 hours. The unit shall have provisions for a self-cleaning drain port to dump condensed liquid water overboard the aircraft.

3.2.1.6.4 Air Filter

The particulate air filter shall remove solid particles, oil droplets, condensed water, and other liquids from the air supply air at the Air Separation Module (ASM) inlet. The filter shall capture a minimum of 99% of any particles and droplets 0.6 microns in size, with an objective of 99.95% of the particles and droplets captured. The unit shall have a maximum pressure drop of 1.5 psid at an air flowrate of 4.5 pounds per minute and shall be designed to operate with supply air pressures and temperatures from 60 to 90 psia and 0^{o} F to 110^{o} F respectively. The filter shall be designed for a proof and burst pressure of 200% and 400% of the nominal ASM supply air pressure respectively, and shall weigh no more than 2 lb with 1.2 lb as an objective.

No filter is required if upstream bleed system filters meet these requirements and no oil contamination is produced by the boost compressor.

3.2.1.6.5 Pressure Regulator

The ASM pressure regulator (located upstream of the ASM) shall regulate supply air pressure to the ASM to 60 ± 5 psig. The regulator's design shall withstand inlet pressures and temperatures from 30 to 135 psia and 60^{o} F to 300^{o} F respectively. The regulator shall weigh no more than 2 pounds, with an objective of 1.5 pounds.

3.2.1.6.6 Air Separation Module

3.2.1.6.6.1 Air Supply

The ASM shall operate on conditioned engine bleed air, with contaminant limits specified in MIL-E-5007C, from the supply air conditioning portion of the OBIGGS. The unit shall operate at an regulated supply air input pressure of 60 psig during all but taxi, idle descent, and very low cruise engine power settings. The unit shall operate at a supply air input pressure of 50 psig during taxi and the low engine power settings. The unit's supply air input temperature shall be controlled to 95^{o} F and never exceed 110^{o} F. Supply air specific humidity levels of 200 grains per pound shall be considered in the unit's design. The unit shall not use more than 4.5 pounds per minute of the conditioned bleed air, with 3.5 pounds per minute as an objective.

3.2.1.6.6.2 Processing

The air separation module (ASM) shall process conditioned engine bleed air to provide a nitrogen rich gas suitable for fuel tank inerting. The ASM shall utilize standard aircraft electrical power, conditioned bleed air, or both to drive its functional processes. Electrical power shall be either 28 VDC, 115 VAC (400 Hz) or 270 VDC.

3.2.1.6.6.3 Performance, Operation, and Characteristics

The nominal inert product gas flowrate output from the ASM shall be 0.65 pound per minute with an oxyg n concentration of not greater than 5% by volume at sea level ambient pressure, and a supply air pressure and temperature of 60 psig and 95^{o} F respectively. The NEA gas flow from the unit shall be delivered to the HP compressor except when the HP compressor has failed, in which case the NEA flow shall be delivered to the emergency by-pass duct. The ASM shall operate continuously throughout the mission.

The ASM product flow the shall be controlled to produce a continuous, constant flow rate of 0.65 + 0.05 lb/min (i.e. a modulating control valve or an electro-pneumatic flow regulator downstream of the ASM).

The ASM shall be insulated to reduce the convective-thermodynamic coupling with the installation environment, and assist in cold-space and heat-soak start-up performance. The ASM shall produce useful inert product gas (maximum oxygen concentration 6%) within 30 minutes after being cold-soaked at -65° F for 3 hours or more, and within 15 minutes after being heat-soaked at 160° F for 3 hours.

The ASM design shall incorporate test ports to facilitate periodic ground checks of its performance, including: 1) ASM supply air pressure and temperature, and 2) inert product gas flowrate and oxygen concentration. The ASM will operate full-time, and shall have minimum MTBF of TBD hrs. The ASM shall have a total weight not to exceed 25 pounds.

The components of the ASM shall be capable of withstanding a proof pressure equal to 150% of normal operating pressure at maximum operating temperature without damage or subsequent performance degradation. However, any pressure regulators shall be able to withstand 200% of maximum bleed air pressure. The components of the ASM shall also be capable of withstanding a burst pressure equal to 300% of normal operating pressure at maximum operating temperature without bursting. The ASM need not meet performance specification after exposure to the burst pressure.

3.2.1.6.7 Modulating Back-Pressure Control Valve

3.2.1.6.7.1 General

The design of the modulating back-pressure control valve portion of the OBIGGS shall be driven by the performance requirements of the ASM, and by the required HP compressor inlet conditions. The major objective of this hardware is to back-pressure the ASM's inert product gas (NEA) flow over a wide range of the ASM's performance map operating points. The ASM must be back-pressured to function as a gas separator device. This valve shall regulate the product flow rate of the ASM to 0.65 $\pm$.05 pounds per minute.

3.2.1.6.7.2 Operation and Characteristics

The modulating valve shall be located as close to the ASM product gas port as is possible for maximum ASM performance control. Long lengths of duct between the

ASM and the back-pressure control valve shall be avoided. The valve shall either be: or 1) a modulating valve with an attached stepper motor controlled electrically using a microprocessor and important sensed property measurements or 2) an electro-pneumatic flow regulating valve.

3.2.1.6.8 Inert Gas By-Pass Duct

3.2.1.6.8.1 General

The design of the inert gas by-pass duct portion of the aircraft's OBIGGS shall be driven by the desired system capability in the event that the high pressure system fails. This duct shall provide a continuous flow of NEA to the fuel tanks from the ASM when there is a problem with the high pressure system.

3.2.1.6.8.2 Operation and Characteristics

The inert gas by-pass duct shall not be used when the high pressure compressor is operating within its specified performance. This procedure shall be accomplished by utilizing an appropriately controlled on/off valve followed by a check valve in the by-pass duct. The on/off valve shall be commanded to open: 1) upon detection of a HP compressor failure and 2) no output flow from the high pressure storage bottles when repressurized gas is required, both via the aircraft avionics Built-In Test (BIT) functions. The by-pass duct shall be sized for the desired ASM product gas flowrate of 0.65 pounds per minute. This valve shall remain open until the high pressure system is sensed to be operating normally.

3.2.1.6.9 High Pressure Compressor

3.2.1.6.9.1 General

The design of the high pressure (HP) compressor portion of the aircraft's OBIGGS shall be driven by the performance requirements of the ASM, the ASM's modulating back-pressure control valve, the inert gas by-pass duct, and the HP inert gas storage bottles. The major objective of the HP compressor is to provide a source of clean, dry, temperature controlled NEA to the high pressure inert gas storage bottles.

3.2.1.6.9.2 Duty Cycle and Control

The HP compressor shall operate continuously upon aircraft electrical power-up to provide a source of pressurized NEA for the HP storage bottles, whose nominal pressure shall be maintained at 3000 psig. Automatic shut-off in the event of a failure or malfunction shall be provided. Surge control shall also be provided.

3.2.1.6.9.3 Inlet Air Source

The HP compressor shall operate on inert output gas from the ASM, which shall flow from the ASM to the compressor through the ASM modulating back-pressure control valve. This inlet air to the HP compressor shall be provided at a minimum pressure and temperature of 30 psia and TBD ^{o} F respectively, and a maximum pressure and temperature of TBD psia and 110^{o} F respectively. The HP compressor shall be designed to handle inlet flowrates of 0.5 to 0.8 pounds per minute. However, as an objective, the HP compressor shall be designed to handle a nominal inlet flowrate of 0.65 pounds per minute.

The HP compressor and motor assembly shall be designed to handle inlet air pressure fluctuations without unduely back-pressuring the ASM gas modulating back-pressure control valve so as to affect ASM performance. The HP compressor shall not cause pneumatic surging to occur in the inlet air duct to the OBIGGS.

3.2.1.6.9.4 Performance, Operation, and Characteristics

The HP compressor shall have a design outlet pressure of 3000 psig with a maximum allowable temperature of 250^{o} F. However, as an objective, this outlet temperature shall be limited to 200^{o} F. Normal compartment ambient pressures and temperatures (excluding hot and cold soak) will range between 0.8 psia to 14.7 psia, and 0^{o} F to 180^{o} F interstage cooling will use liquid (coolanol -25) as an objective. Air cooling may be used if it meets the compression outlet temperature requirements over the range if specified ambient conditions. The compressed outlet air shall be clean, and have a maximum allowable compressor lubrication oil contamination of TBD ppm. A flow check valve shall be provided at the compressor's outlet.

The HP compressor shall:

- Have an MTBF of no less than 2,000 hours with an objective of 2,500 hours;
- Have power requirements not to exceed approximately 15 kW of either 28 VDC, 115 VAC (400 Hz) or 270 VDC aircraft electrical power;
- Be packaged and designed to operate with an electric motor and a variable speed controller;
- Not weigh more than 70 pounds (including its motor), with a weight of 60 pounds (including its motor) as an objective;
- Be designed to minimize heat rejection to the installation location.

3.2.1.6.9.5 Monitoring

The process gas (NEA) pressure and temperature upstream and downstream of the boost compressor shall be monitored, as will be either the compressor's electric motor temperature or electrical current level. The compressor's lubricating oil level and temperature shall also be monitored along with excessive compressor vibration. These variables shall provide data for both system operation, failed/operational monitoring using compressor RPM or outlet pressure and BITE.

3.2.1.6.9.6 Indication

Automatic compressor shutdown capability and pilot warning shall be provided upon BIT detection of an excessively high compressor lubricating oil temperature, outlet air temperature (>250° F), outlet air pressure (>3500 psig), excessive vibration, a low electrical current level (<TBD amps), or a low lubricating oil level pressure.

3.2.1.6.10 High Pressure Storage Bottles

3.2.1.6.10.1 General

The design of the high pressure (HP) storage bottles shall be driven by the performance requirements of the high pressure compressor, inert gas delivery system and by installation issues concerning airframe, equipment, and personnel safety. The major objective of the HP storage bottles is to accumulate an adequate quantity of clean, dry NEA (from the HP compressor) for on-demand release into the inert gas distribution system. This ensures that fuel tank inerting gas flow requirements are met.

3.2.1.6.10.2 Performance, Operation, and Characteristics

The HP storage bottles shall be designed for a nominal stored gas (NEA) pressure of 3000 psig and a temperature of 390^{o} F and hold a minimum of 50 pounds of NEA. The bottles shall be designed for a maximum compartment temperature of 180^{o} F.

The HP bottles shall functionally serve as pneumatic accumulators and will be charged and discharged more than once during an aircraft mission. Stored gas may be entering the bottles from the high pressure compressor while simultaneously exiting the bottles into the inert gas distribution system. Installation concerns shall dictate whether a cylindrical or spherical bottle design is used. In the event composite bottles are used, leakage rates, and stored gas temperature values shall dictate which liner material is used inside the bottles (e.g., an elastomer, aluminum, or stainless steel). Maximum compartment temperature values shall be used to determine the type of composite fiber resin system.

Pressure relief provisions shall be incorporated into the HP bottle installation to relieve excess stored gas pressure. (This configuration is required because the HP compressor is designed to operate continuously). A minimum proof and burst pressure of 200% and 400% respectively, shall be used in the bottle design. The high pressure storage system shall include provisions for condensate drain.

The HP bottles shall be installed and secured such that they will not break loose from their cradles if punctured and cause damage to nearby equipment.

Blow-out panels shall be incorporated in the equipment bay where the HP bottles are installed to prevent airframe damage from compartment over-pressure in the event the bottles are punctured. A rigid blanket or suspended shield made of a composite material (i.e., Kevlar) shall be utilized to protect the HP bottles from ballistic/weapon fragments as well as to protect nearby equipment from damage caused by a bottle puncture. The bottles shall be designed to fail by leakage rather than rupture when hit by a single tumbling .50 caliber projectile. The bottles shall be nonshatterable.

If several bottles are used, their weight shall not exceed 40 pounds each, with a weight of 25 lb each as an objective. The HP bottles shall be designed to minimize stored gas leakage through their liners. Provisions for stored gas quantity and quality by maintenance personnel shall be incorporated into the bottle design. The bottles shall be designed for 10,000 operational (internal) pressure and temperature cycles.

3.2.1.6.11 Inert Gas Distribution System

3.2.1.6.11.1 High Pressure Gas System

Pressure reduction of the NEA downstream of HP storage bottles shall be 2 stage, high pressure regulator and demand regulators in the vent system. A high pressure regulator shall be used to reduce NEA from the nominal 3000 psi bottle pressure to TBD $\pm$ TBD for delivery to the demand regulators. A flow limiting device such as a venturi shall be used with the regulator to protect downstream components in the event of regulator failure. An objective shall be to optimize the NEA delivery pressure in each duct to minimize duct size and weight while meeting pneumatic duct safety requirements.

3.2.1.6.11.2 Low Pressure Air System

There shall be a controlled shut-off valve to isolate the low pressure and high pressure ducting. Demand regulators shall be used downstream of the on/off valves in low pressure duct to control the quantity and flow of NEA from the HP bottles to the fuel tanks. These regulators located in the vent system shall regulate the flow of NEA into the vent system to maintain minimum scheduled tank pressure. The inlet and outlet pressure ranges of these demand regulators are TBD. The demand regulators shall maintain the fuel tank pressure at a 1 psig or 6.5 psia, whichever is greater, except during ground or refueling operations.

3.2.1.6.11.3 Fuel Tank Vent System

The aircraft fuel tank vent system shall consider the applicable interface issues with the OBIGGS. The vent system will be designed to minimize the loss of NEA overboard the aircraft through the climb valves during ground and aerial refueling. In addition, the OBIGGS shall be designed to prevent NEA flow to the fuel tank during aerial refueling. A high pressure build-up in the tanks in the event of a control valve failure shall be avoided.

The OBIGGS/vent system design shall consider fuel tank feed sequence. The OBIGGS/vent system design shall consider over-wing single point refueling using a universal refueling slipway installation. Check valves with a minimum pressure setting of 5 inches of water shall be used in the OBIGGS distribution ducts (i.e., scrub, wash, and repressurization ducts) which connect to the vent box. Each of these valves shall incorporate two float valves, one for normal flight and one for inverted flight, to prevent fuel from entering the vent system.

3.2.1.6.11.4 Fuel Scrubbing System

A minimum of 21 pounds of NEA shall be stored in the High Pressure bottles from the previous mission. During the taxi and through the initial climbout (if necessary) NEA shall be bubbled through the scrub nozzles located on the bottom of the tanks at a rate of 2.1 pounds per minute for 10 minutes. The scrub nozzles shall be designed so that removal of dissolved oxygen from the fuel shall be less than 50% of the maximum or equilibrium amount which can be removed from the fuel. This will minimize ullage uninert time during fuel scrubbing. The scrub orifice and scrub nozzles shall limit the scrub flow rate to 2.1 lb/min. The inlet pressure and outlet pressures of the scrub orifice (TBD) shall be considered in conjunction with the design of the scrub nozzles. Orifices in line to each tank shall limit the actual scrub into each tank according to a ratio of the tank volume and the total tank volume.

3.2.1.6.12 Control/Interface Processor

3.2.1.6.12.1 General

The design of the control/interface processor portion of the OBIGGS shall be driven by: 1) the overall aircraft avionics architecture, including data and power buses, 2) the number of sensed and controlled OBIGGS parameters, 3) the number of built In Test (BIT) functions and desired level of hardware diagnostics to be performed, and 4) the provisions to off-load hardware status data to the aircraft maintenance computer. The major objectives of the control/interface processor will be to: 1) provide the necessary control of OBIGGS hardware (i.e., on/off valves, modulating valves, and compressors) for optimum system operation, 2) monitor hardware status for required maintenance action and failures, 3) communicate with other aircraft avionic processors to receive and send pertinent OBIGGS data, for either in-flight status or on-ground maintenance and 4) enable the OBIGGS to operate as a fully automatic, self-compensating system which does not require any manual adjustment by the pilot.

3.2.1.6.12.2 Analog-to-Digital and Digital-to-Analog Converters

Analog-to-Digital converters shall be used to receive OBIGGS hardware status data into the Control/Interface Processor, while Digital-to-Analog converters shall be used to send control signals from the processor the to OBIGGS hardware.

3.2.1.6.12.3 Operation and Characteristics

The Control/Interface Processor shall be continuously fed with data from both aircraft and dedicated OBIGGS sensors monitoring all relevant conditions (i.e., OBIGGS Unit supply air pressure and temperature, aircraft altitude, and OBIGGS unit inert product gas flowrate and oxygen concentration/partial pressure). The processor shall compare these inputs with its pre-set program of optimum parameter values to obtain the required inert product gas conditions. Deviation from preset tolerances shall set appropriate messages to on board fault detection and monitoring hardware. If an active electronic controller is used, it will initiate the appropriate system control action to achieve the desired results. Thus, as an objective a closed-loop, active feedback control approach will be used (versus open-loop control).

The OBIGGS shall be designed to function as an integrated system, which shall be monitored and controlled by the Control/Interface Processor (shown conceptually in Figure 7). The software algorithms shall be designed to take full advantage of inherent system performance capabilities, while minimizing penalties to the aircraft.

A typical schematic of the electrical interface of the processor with the rest of the OBIGGS is shown in Figure 8. Control parameters (both analog and digital shall be conditioned by the appropriate circuitry before being used by the processor to determine required control variable setting.

Drive circuitry shall be provided for any OBIGGS solenoid valves and other system controls and indicators. Built-In Test (BIT) functions (i.e., fault detection/isolation) shall be incorporated in the processor to detect system hardware failures and provide hardware maintenance tracking features.

3.2.1.6.13 Sensors

3.2.1.6.13.1 General

The design of various sensors for the aircraft's OBIGGS shall be driven by the performance requirements of the OBIGGS, as well as the overall OBIGGS control scheme. The major objectives of these sensors will be to monitor hardware status and provide feedback data for hardware control.

3.2.1.6.13.2 Oxygen Concentration

An oxygen concentration sensor shall be used to sense inert product gas oxygen concentration in the gas (NEA) flow leaving the ASM, and venting through the fuel tank ullage volumes. These sensors shall continuously monitor the oxygen partial pressure of the inert gas flow flow, and possess BIT function capabilities to detect sensor or system failure.

The sensors shall be designed for rapid response with minimum sensor lag time and warm-up time. The response time shall be 90% response to a step function change in sample gas oxygen partial pressure within 15 seconds at a gas temperature of 75° F, or 45 seconds at 32° F. The sensors shall also be designed for high reliability and infrequent, yet simple maintenance actions.

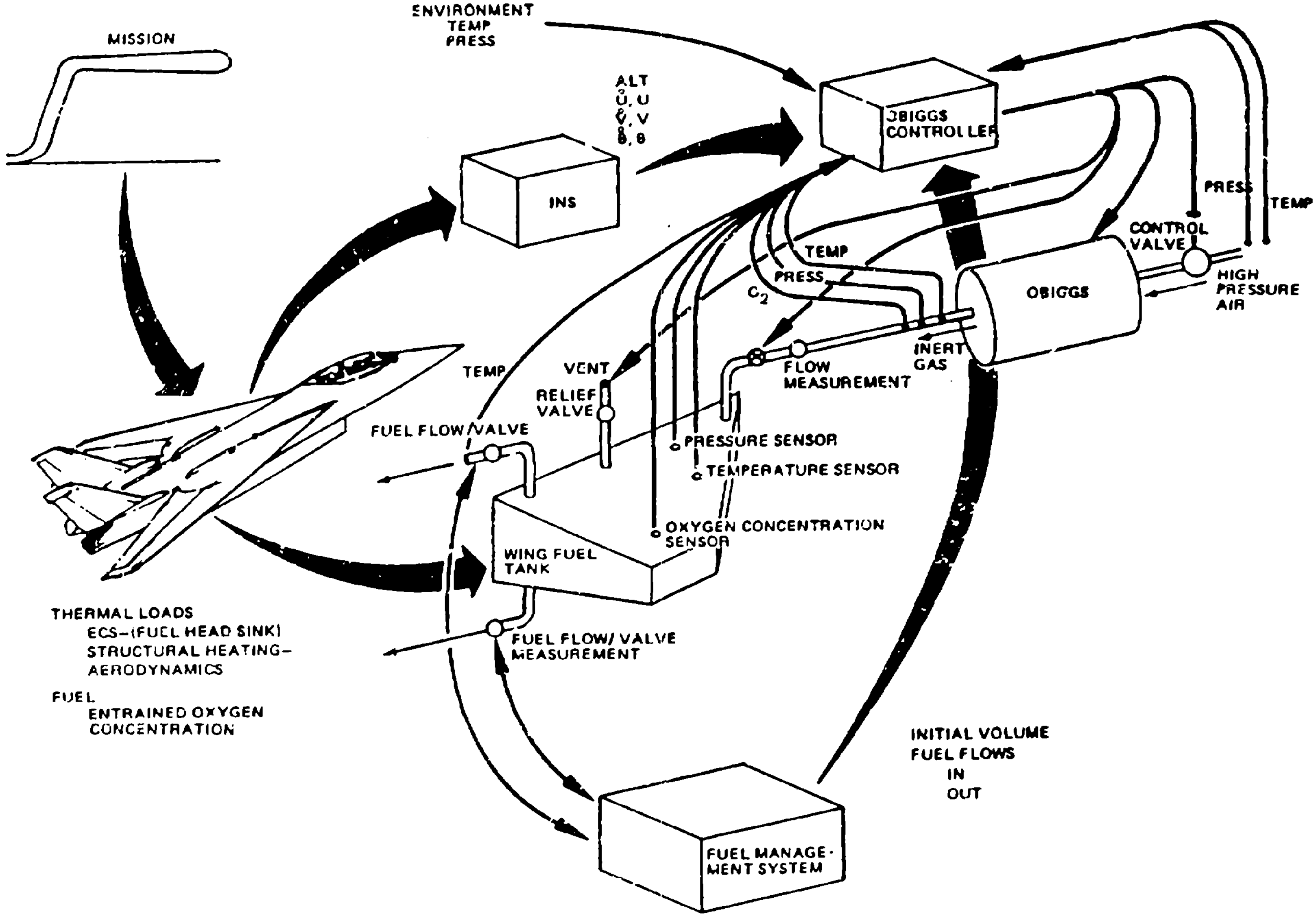

Figure 7. OBIGGS Control System

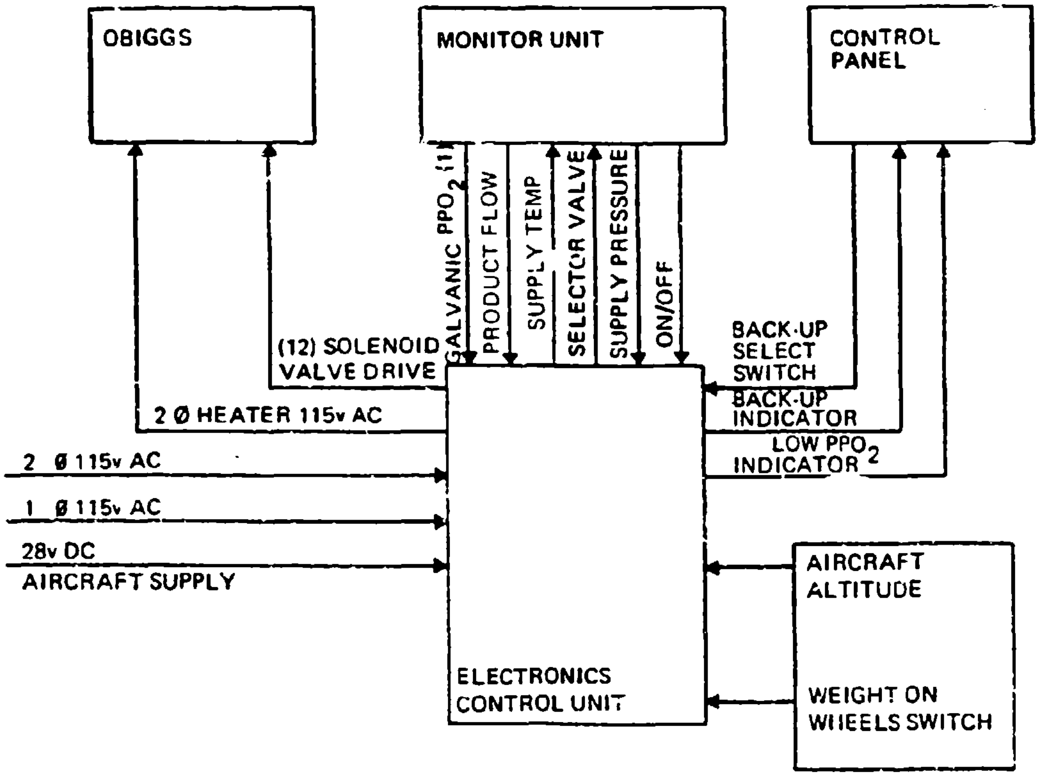

Figure 8. OBIGGS Microprocessor Electrical Interface

As a minimum, these sensors shall be threshold devices generating a signal within 15 seconds of oxygen partial pressure climbing above 12% O_2. The sensors shall be capable of measuring sample gas oxygen concentration in the range of 1% to 25% O_2 (volume %). The sensors shall have an accuracy (i.e., % error full scale) of 3% (or less if possible) and reproducibility (i.e., measurement drift) of 5% of full scale for a minimum time of 2000 hours.

The specified performance of the oxygen sensors shall not be affected by: 1) specified aircraft vibration and acceleration levels, 2) water vapor (relative humidity to 100%) and aviation fuel vapors in the sample gas, 3) operating pressures from 30 psig to 90 psig, 4) ambient pressures of 1.0 to 15.5 psia, 5) operating and storage temperatures of 30^{o} F to $+130^{o}$ F, 6) heat soaking at $+160^{o}$ F and cold soaking at -65^{o} F for a minimum of 3 hours, and 7) rapid changes in sample gas pressure and temperature.

3.2.1.6.13.3 Pressure Transducers

A pressure transducer shall be used to sense gauge pressure of the gas flow to the supply air boost compressor of the ASM, to the ASM itself, and of the inert product gas flow leaving the ASM. The inert gas (NEA) pressure inside the high pressure storage bottles shall also be measured. If any flowmeters are used for ASM control, then two pressure transducers shall be used in conjunction with this flowmeter (potentially located immediately downstream of the ASM's modulating back-pressure control valve).

These transducers shall continuously monitor duct gauge pressure and possess BIT function capabilities to detect transducer or system failure. As an objective, these units shall be used in the OBIGGS inert product gas oxygen concentration and flow scheme.

The transducers shall be designed for rapid response, high reliability and infrequent, yet simple maintenance actions. As a minimum, these transducers shall be threshold devices generating a signal within 15 seconds of a measured duct pressure which is 15% lower than the specified design pressure value. Transducers with a measurement range of 0 to 150 psig, 0 to 100 psig, and 0 to 3500 psig shall be required.

The specified performance of the pressure transducers shall not be affected by: 1) specified aircraft vibration and acceleration levels, 2) water vapor (relative humidities to 100%) and aviation fuel vapors in the gas entering the sensing ports, 3) ambient pressures of 1.0 to 15.5 psia, 4) operating and storage temperatures of 30° F to +300° F, 5) heat soaking at +160° F and cold soaking at -65° F for a minimum of 3 hours, and 6) rapid changes in sample gas pressure and temperature.

3.2.1.6.13.4 Temperature Transducers

Temperature transducers or other temperature measuring devices shall be used to sense temperature of the gas flow to supply air boost compressor of the ASM, to the ASM itself, and of the inert product gas flow leaving the ASM. The inert gas (NEA) temperature inside the high pressure storage bottles shall also be measured. A single thermocouple shall be used in conjunction with the flowmeter (potentially located immediately downstream of the control valve of the ASM). As an objective, thermocouples will also be used to fault monitor compressor operation when electric motors are used to drive the OBIGGS's compressors.

These temperature sensors shall continuously monitor gas temperature in the duct or location they are installed in. As an objective, these units shall be used in the OBIGGS overall control scheme. As a minimum, these temperature sensors shall be threshold devices generating a signal within 10 seconds of a measured duct temperature or compressor temperature which is 15% higher than the specified design temperature value. Temperature sensors with a measurement range of 0° F to 300° F shall be required.

3.2.1.6.13.5 Flowmeters

The mass flow rates of the product gas of the ASM and the output of the pressure storage bottles shall be measured using standard measuring techniques. The flowmeter shall provide the necessary information to the aircraft data bus to control the ASM product flow rate to 0.65 $\pm$ 0.05 pounds per minute using a back pressure control valve with a minimum range of 0-1 pound per minute. The high pressure bottle output flowmeter shall have a range of TBD pounds per minute. with an accuracy of $\pm$ TBD %.

3.2.1.6.13.6 Motion Transducer

A motion transducer, or an equivalent functional device, shall be used along with the modulating ASM back-pressure control valve to provide valve (if used) control.

3.2.1.7 Interface Requirements

3.2.1.7.1 External Interfaces

The OBIGGS system shall interface with the Environmental Control and Thermal Management Systems and the integral wing/body fuel tanks.

3.2.1.7.1.1 External Systems Description

The aircraft Environmental Control System shall supply air at the pressures and temperatures specified herein. This system also includes the filters and water separators required to reduce the effects of ASM supply air contamination.

The distribution system shall deliver NEA from the ASM to the aircraft fuel tanks. The system shall interface with the intertank fuel transfer and crossfeed system through the appropriate valves and fittings.

3.2.1.7.1.2 External Interface Identification

External interfaces are shown in Figures 4 and 5.

3.2.1.7.1.3 Hardware-to-Hardware External Interfaces

The OBIGGS interface to the distribution system shall be through ducting which meets the requirements stated in MIL-E-38453A and the intent of ARP699C.

System components shall utilize a nominal 115 VAC (400 Hz), or 28 VDC, per MIL-STD-704D or 270 VDC. The OBIGGS shall consume no more than TBD KW maximum power. Other components including heaters for the OBIGG unit, if necessary, shall consume no more than a total of TBD KW.

Electrical power quality requirements shall be compatible with the given aircraft's power quality and within MIL-STD-704D, Category B. Electrical overload protection shall be in accordance with MIL-STD-454H(3), Requirement 8. All solenoids, if used, shall be in accordance with MIL-S-4040D(1).

Electrical connectors shall conform to MIL-C-83723D(1), Series III, bayonet type as applicable. Wiring shall conform to MIL-W-22759D(1), MIL-C-81044B(1A), or MIL-W-81381A(1B) applicable. Electrical connections shall be fitted with clean, durable shippings caps in accordance with MS90376C as applicable.

All electronic circuitry (both data and power interfaces) shall be tolerant of accidental connection to either side of the power bus and to inadvertent polarity reversal of input power. All electronic and electrical components shall be tested in accordance with MIL-STD-202F(5).

The OBIGGS shall be electrically connected to the aircraft data systems. The system shall receive, interpret, and validate the data from the aircraft data system. The system shall communicate BIT data to the central aircraft BIT display software.

3.2.1.7.1.4 Hardware-to-Software External Interfaces

Hardware to software external interfaces shall be as detailed in 3.2.1.6.12.

3.2.1.7.1.5 Software-to-Software External Interfaces

Software-to-Software external interfaces will be between the BIT of the Controller Processor and aircraft status and warning systems in a format and with values compatible with aircraft systems.

3.2.1.7.2 Internal Interfaces

The internal interfaces shall be as shown in Figures 4 and 5 and as described in Section 3.2.1.6 and subparagraphs thereto.

3.2.1.8 Government Furnished Property

The OBIGGS shall not include any Government Furnished Equipment in its design. Government Furnished Information shall include the physical and elecronic inputs available to the OBIGGS from the aircraft and the format required.

3.2.2 System Characteristics

3.2.2.1 Physical Requirements

The weight of the OBIGGS shall not exceed the weight of typical foam inerting installations on existing tactical aircraft. This weight limit is on the order of 300 pounds. As an objective, the OBIGGS entire installation weight will be no greater than 300 pounds with an installation package volume no greater than 8.0 cubic feet (including the increased cooling systems size for cooling the bleed supply air).

Equipment shall not generate noise in excess of maximum allowable levels prescribed by MIL-A-8806B, or AFR 161-35 as applicable. The design will mconsider the effect of system operation in the vicinity of the head of flight or ground personnel. Noise abatement measures will be taken to assure that system operation will never expose unprotected personnel to noise levels that exceed 135 dB in any octave band.

Any deliverable components and systems will meet preservation, packaging and packing requirements derived from MIL-STD-1188A, Level C, FED-STD-102B, PPP-B-636H(1), PPC-C-1752A(1), and PPP-B-6101F(2) as applicable.

3.2.2.2 Environmental Conditions

The OBIGGS shall not suffer any detrimental effects as a result of exposure to any combination of the environments specified herein. It shall be capable of meeting all performance requirements when operated during, or after, any of the environmental tests described herein.

The system shall operate within specifications when exposed to altitudes up to 70 kft. The equipment shall deliver the required performance while withstanding the temperature altitude tests specified in MIL-STD-810C, Method check 504.1, Procedure I. The maximum altitude tested shall be 70 kft.

The equipment shall deliver the specified performance, while withstanding the high temperatures specified in MIL-STD-810C, Method 501.1, Procedures I and II. The highest temperature under which the equipment shall deliver the specified performance is 125° F. Operation and storage of the hardware in the range of 125° F to 160° F is also required. However, the inert product gas flowrate and oxygen concentration requirements shall be waived.

The equipment shall deliver the specified performance while withstanding the low temperatures specified in MIL-STD-810C, Method 502.1, Procedures I. The lowest temperature under which the equipment shall deliver the specified performance is 0° F. Operation and storage of the hardware in the range of -65° F to 0° F is also required. However, the inert product gas flowrate and oxygen concentration requirements shall be waived.

The OBIGGS equipment shall operate, deliver the specified performance, and be transportable at aircraft altitudes from sea level to 70 kft in accordance with MIL-STD-810C, Method 500.1, Procedure I, and MIL-A-8421F respectively.

The OBIGGS equipment shall be capable of operating, and deliver the specified performance, in any position/orientation, and for any length of time incident to the aircraft's flight maneuvers.

The equipment shall be capable of operating, and deliver the specified performance, when exposed to the humidity test conditions specified in MIL-STD-810C, Method 507.1, Procedure I or II. The equipment shall also deliver the specified performance and not suffer any detrimental effects after being subjected to relative humdities up to 95% at ambient temperatures up to 160° F.

The OBIGGS components shall deliver the specified performance and not suffer any detrimental effects after exposure to rain conditions described in AR-70-38, and in MIL-STD-810C, Method 506.1, Procedure I.

The equipment's corrosion resistance shall be evaluated in accordance with MIL-STD-810C, Method 509.1, Procedure I, and shall deliver the specified performance and not suffer any detrimental effects after being subjected to the conditions of AR-70-38, Category 2. In addition, the equipment shall perform satisfactorily, and its endurance capability and useful life shall not be adversely affected while operating in, or after exposure to, salt laden air.

The OBIGGS equipment shall deliver the specified performance and not suffer any detrimental effects from being subjected to the blowing conditions described in AR-70-38, Category 4, and in MIL-STD-810C, Method 510.1, Procedure I.

The OBIGGS equipment shall deliver the specified performance and not suffer any detrimental effects from being exposed to the internal sand and dust conditions of MIL-T-83116A.

The OBIGG's equipment shall deliver the specified performance and not suffer any detrimental effects from being exposed to the fungi specified below as described in MIL-STD-810C, Method 508.2, Procedure I.

Fungus Groups

Fungi	ATCC No.	USDA No.
Aspergillus niger	9642	386
Aspergillus flavus	9643	380
Aspergillus versicolor	11730	432
Penicillium funiculosum	11797	474
Chaetomium globusom	6205	459

Line replaceable units (LRU's) required to operate in a potentially explosive atmosphere shall be tested in accordance with MIL-STD-810C, Method 511.1, Procedure I. The OBIGGS shall not ignite an explosive atmosphere and shall not suffer any detrimental effects from operating in an explosive atmosphere.

The equipment shall deliver the specified performance while withstanding the vibrational stresses specified in MIL-STD-810C, Method 514.2, Procedure IA, Category b.2, and in NAVMAT P-9492 as applicable to the given fighter aircraft.

The equipment shall be tested in accordance with MIL-STD-810C, Method 516.2, Procedure I. In addition it shall withstand without performance degradation, mechanical shocks of 40 g (sine waveform) amplitude from any direction for a duration of 2 milliseconds, or the most appropriate shock level and duration for the given fighter aircraft.

The equipment shall be tested in accordance with MIL-STD-810C, Method 513.2, Procedure I and II. In addition, the equipment shall deliver specified performance while withstanding steady state acceleration levels of +9 Gz, -3 Gz, ±6 Gx, and ±2 Gy, or the most appropriate acceleration levels for the given fighter aircraft.

The equipment shall deliver the specified performance while withstanding the gunfire vibrations levels specified in MIL-STD-810C, Method 519.2, Procedure I.

The equipment shall deliver the specified performance while withstanding the acoustical noise levels specified in MIL-STD-810C, Method 515.2, Procedure I, Category A.

The equipment shall be capable of operating, and deliver the specified performance, when exposed to the temperature, humidity, and altitude test conditions specified in MIL-STD-810C, Method 518.1, Procedure I.

3.2.2.3 Nuclear Control Requirements

There are no nuclear control requirements in this system.

3.2.2.4 Materials, Processes, and Parts

Materials and components shall conform to applicable specifications as specified herein. Materials, processes, and parts shall be selected in the order of precedence set forth in MIL-STD-143B and ADS 13B. Materials and components which are not covered by applicable specifications, or which are not specifically described herein, shall be of the highest quality, lightest practicable weight, and entirely suitable for the purpose intended. The use of standard parts is advocated. However, this is secondary to the prime objective of meeting system performance requirements.

Any materials that deteriorate, or are otherwise affected by continued service with nitrogen shall not be used in the OBIGGS, or the fuel system. Materials exposed to fluids normally used in military aircraft shall be resistant to damage by such fluids.

Metals shall be corrosion resistant, or suitably treated to resist corrosion caused by fuels, salt spray, and atmospheric conditions likely to be met in storage and in normal service.

Dissimilar metals, such as defined by MIL-STD-889B(1) shall not be used in intimate contact with each other unless suitably protected against electrolytic corrosion.

All castings shall be classified for and inspected in accordance with MIL-C-6021H(1).

Welding shall be in accordance with MIL-W-6858D, MIL-W-6873B, MIL-W-8604A, and MIL-W-8611A. Brazing shall be in accordance with MIL-B-7883B.

Heat treatment of aluminum and steel parts shall be in accordance with MIL-H-6088F(1) and MIL-H-6875G respectively.

Threads shall be in accordance with MIL-S-8879A(1).

Tapered pipe threads may not be used except to permanently plug drilled holes. When used, they shall comply with MIL-P-7105B(1).

All threaded connections in nonferrous materials shall have steel inserts that are suitably protected from electrolytic corrosion. Fill and drill boss inserts shall be designed to permit the use of standard gaskets or seals and standard straight-threaded plugs.

All threaded parts shall be securely locked by safety wiring, self-locking nuts, cotter pins, or other military standard methods.

Fasteners, for mounting or assembly, utilizing self-locking features in accordance with MS33588D shall be used where possible in preference to safety wiring or cotter pinning. When the use of safety wiring or cotter pinning cannot be avoided, safety wiring and cotter pinning shall be employed in accordance with MS33540H.

Electrical bonding shall be in accordance with MIL-B-5087B(2), Class H, and shall not prevent installation or removal of the equipment.

Any nonmetallic material that is adversely affected by continued use with nitrogen shall not be used in contact with the NEA. Also, materials which are nutrients for fungi shall not be used in the OBIGGS's construction. Nonmetallic seals, gaskets, grommets, and similar items used in the components shall be compatible with the environmental conditions specified herein.

All elastomers shall be free from foreign agents that might cause objectionable or intolerable odors. Elastomer components shall be controlled in accordance with MIL-STD-1523A.

Advanced composite materials may be graphite/epoxy, Kevlar, or fiberglas reinforced organic polymer matrix composites or hybrid combinations. All advance composite components shall be finished with pin hole filler, surfacer, and a suitable enamel coating as required for appearance and/or abrasion resistance. Composites are not subject to corrosion, however, certain metals must be protected when they are in contact, particularly with graphite materials. All aluminum fittings coming in contact with graphite faying surfaces shall be adequately protected against galvanic corrosion by the addition of one ply of 120 style fiberglass or Kevlar prepreg on the graphite faying surface, extending at least 4 inches beyond the aluminum metal faying surface. In addition, a chromated polysulfide type sealant shall be applied to the aluminum faying surface and the fasteners (either corrosion resistant steel or titanium) shall be wet installed with the same sealant. The aluminum part(s) shall have one coat of primer plus one coat of enamel.

Materials subject to deterioration or corrosion during service shall be protected in accordance with MIL-S-5002C(1). Materials specifically subject to corrosion in nitrogen, salt air, or any other atmospheric conditions likely to occur during service usage shall be protected against such corrosion as well. The protective treatment shall be such that it will in no way prevent compliance with the OBIGGS performance requirements specified in this document, or hinder or prevent the intended use of the items. The use of any protective coating that will crack, chip, or scale with age or extremes of atmospheric conditions shall be avoided.

Aluminum and aluminum alloy parts shall be protected in accordance with MIL-C-5541 or MIL-A-8625C(1). Finish and protective coatings shall be in accordance with MIL-F-7179F(1), MIL-F-18264D(1), MIL-C-817065, and MIL-C-83286B(2) as applicable.

The equipment shall be constructed so that parts will not work loose in service. Equipment shall be built to withstand the strains, jars, vibrations, and any other conditions incident to shipping, storage, installation, and service. The OBIGGS shall utilize fittings to ensure all plumbing is leak tight.

Riveting or welding may be used in the construction of the OBIGGS where permanent attachments are made. Fittings and joints requiring disassembly for maintenance shall be attached by bolting or other suitable removeable attachment.

All openings in the equipment shall be closed with caps or plugs to prevent dust and any foreign matter from entering the equipment during the shipment and storage. All caps and plugs, and dust and moisture seals shall conform to the requirements of MIL-C-5501F(1), and MS90376C as applicable.

Lubricants and lubrication shall conform to the requirements of MIL-STD-838C. Lubrication shall function satisfactorily within the temperature range of -65° F to +160° F. However, the most appropriate upper lubrication temperature limit for the given hardware (i.e., high pressure compressor) shall be used if it exceeds +160° F.

3.2.2.5 Electromagnetic Radiation

The OBIGGS shall be designed to consider electromagnetic environmental effects which includes: electromagnetic compatibility (EMC), electromagnetic interference (EMI), lightning electromagnetic pulse (LEMP), and nuclear electromagnetic pulse (NEMP).

The equipment shall be tested and shall comply with the applicable electromagnetic emissions and susceptibility requirements of MIL-STD-461B and MIL-STD-462(4) for equipment Class A1, Category Alb. Electronic circuitry and enclosures shall be designed to eliminate vulnerability, or hamper system performance due to electromagnetic pulse, line transients (i.e., high pressure compressor electric motor startup), lightning, or static electrical discharge. The design shall be electromagnetically compatible with the intrasystem, and mission electromagnetic environment to ensure the OBIGGS and its subsystems operate without malfunction or degradation. Compatibility testing shall be accomplished in accordance with MIL-E-6051D(1).

The EMC/EMI program plan shall be tailored from MIL-STD-461B to include specific tests for the given airplane development program, and shall be accomplished in accordance with MIL-STD-462(4).

3.2.2.6 Workmanship

The workmanship employed in the manufacture of all parts and assemblies shall be in accordance with high-grade aircraft practices and quality to ensure safety, proper operation, and service. The finished assemblies and all integral parts shall be clean and free of oils and any other materials that might adversely affects its operation. Acceptable workmanship criteria for electronic equipment shall be in accordance with MIL-STD-454H(3), Requirement No. 9. Acceptable workmanship criteria for ground and associated system equipment shall be in accordance with MIL-W-27076(1).

The OBIGGS, including all parts and accessories, shall be developed and finished with craftsmanship, cleanliness, and neatness. Particular attention shall be given to freedom from burrs and sharp edges, accuracy of dimensions, radii, fillets, and marking of parts and assemblies, as well as thoroughness of welding, brazing, painting, riveting and machine finishing, and alignment of parts and tightness of assembly screws and bolts, etc. The OBIGGS shall be free of any projections or sharp edges which could snag, jam, or damage clothing and equipment, maintenance personnel, or foul personal equipment.

3.2.2.7 Interchangeability and Replaceability

All parts, subassemblies, and assemblies having the same part number, except Air Force approved matched sets, shall be functionally and dimensionally interchangeable with each other in respect to installation and performance, as defined in MIL I-8500D. Matched sets will be awarded, and are defined as those parts (i.e., special application parts), which are machine matched or otherwise mated for which replacement as a matched set or pair is essential.

Replaceable components shall be designed to preclude improper installation which could adversely affect the proper functioning of the OBIGGS or its subsystems. The designs should make it physically impossible to mis-install rather than using color coding.

3.2.2.8 Safety

The primary safety considerations shall be to eliminate or control failures, or combinations of failures which could: 1) cause injury to flight or ground personnel, and 2) damage the aircraft fuel system, ECS, or flight equipment installed near the OBIGGS. The design of the OBIGGS shall minimize the probability and severity of injury to personnel throughout its service life.

All equipment shall be developed in compliance with MIL-STD-882B and AFR DH-1-6.

All potential hazards which cannot be eliminated shall be identified through risk analysis.

All equipment shall be airworthy and shall not create hazards within the operational envelop, or state limitations/restrictions of anticipated aircraft operation and/or equipment use. A probable single failure of the OBIGGS or its components shall not cause a hazardous flight condition. Aircraft vulnerability to multiple component failures shall be minimized by appropriate system fail-safe design or shut-down invoked either manually or automatically.

All critical pneumatic and electrical lines for the OBIGGS routed through potential fire zones shall be appropriately "hardened" to prevent damage to those lines, thus reducing the potential of a non-functioning system in an emergency.

Fail-safe features will be incorporated in the design to ensure against hazardous failure. Fail-safe operation shall award maximum system performance if lack of such performance would cause damage to the airframe. For those instances in which component failures would result in a hazardous condition and fail-safe principles are not possible, redundant components or systems will be included in the design. Redundancies will be added to those critical components whose operation is essential to the safe operation of the equipment. These principles will be adhered to in the following cases as a minimum.

Redundancy management and fail-safe fault tolerance shall be provided by the control hardware during automatically controlled system operation.

Fail-safe logic shall be included in the design of the controller software so that software anomalies will have a benign effect on continued system operation.

The design will include measures to prevent inadvertent operation of all active system elements.

The design of the equipment will be such as to provide maximum convenience and safety to personnel while installing, operating, and maintaining the equipment. The system will be free of sharp projections or edges which could cause injury or jeopardize operation of key system components. Equipment design will include provisions to prevent damage when equipment is operated in non-normal manner. Any high pressure pneumatic storage bottles are used in the OBIGGS they shall meet the requirements stated in MIL-C-7905(42) and MIL-A-25363D(2).

The design shall provide positive means to prevent the inadvertent reversing or mis-mating of fittings, hydraulic lines, pneumatic lines, mechanical linkage, and electrical connections. When prevention of mis-mating by design considerations is not feasible, coding or marking shall be employed. Materials that emit toxic smoke or corrosive fumes when subjected to heat, or that are flammable, shall not be used in the OBIGGS. Materials shall not emit gases which combined with the atmosphere form acids or corrosive alkali. Electrical bonding of system components will be performed in accordance with MIL-B-5087B(2) to prevent equipment damage or personnel injury due to lightning discharge, electrostatic charges, induced radio frequency voltages, and accidental short circuits.

Grounded shields will be used on all system wiring to prevent explosion hazards or electrical system damage due to electromagnetic interference and electrostatic charges. Shields will be grounded to the chassis using the method of AFR DH-1-6.

3.2.2.9 Human Factors/Human Engineering

The OBIGGS's equipment shall be developed in accordance with applicable human engineering requirements contained in MIL-H-46855B(2).

Design procedures shall incorporate the relevent guidance and requirements contained in AFR Design handbook DH-1-3 for human factors engineering, MIL-STD-850B for vision, and MIL-STD-1472C(2) for systems, equipment, and facilities. MIL-STD-1472C(2) will be the basis for maintenance considerations. Any system status integrally illuminated information panels shall conform to the requirements of MIL-P-7788E(1).

Human factors engineering principles shall be applied to all design aspects involving a man/machine interface in accordance with MIL-STD-1472C(2). The ASM package shall be designed for removal and replacement by 95th percentile mechanics working in an arctic environment and wearing arctic clothing, including arctic weight handwear and other garments. Considerations for mechanics working in a NBC environment wearing NBC protection gloves shall also be considered.

3.2.2.10 Deployment Requirements

The OBIGGS shall be capable of thirty days of deployed operation without additional airlift support.

3.2.2.11 System Effectiveness Models

System Effectiveness Models shall be developed to demonstrate system performance and interface capability.

3.2.3.3 Processing Resources

3.2.3.3.1 Controller/BIT Processing Resource

The OBIGGS Controller shall be capable of process ıputs from the aircraft computers and supplying status to the aircraft mission computers.

3.2.3.3.1.1 Computer Hardware Requirements

The OBIGGS Controller shall possess the following characteristics:

Memory Size	TBD
Word Size	TBD

Processing Speed	TBD
Character Set Standard	TBD
Instruction Set Architecture	TBD
Interrupt Capabilities	TBD
Direct Memory Access	TBD
Channel Requirements	TBD
Auxiliary Storage Requirements	TBD
Growth Capabilities	TBD
Diagnostic Capabilities	TBD
Additional Requirements	TBD

3.2.3.3.1.2 Programming Requirements

The current versions of AFR 300-10 standard higher-order programming languages shall be used in all systems of software development.

3.2.3.3.1.3 Design and Coding Constraints

Statements and subroutines written in non-standard code shall in all cases be clearly identified as non-standard code and shall, where possible, be separated from the standard code. Computer programs, regardless of media, shall be written using top-down structured programming techniques. Programs shall be structured using the computer program configuration item, and component definitions of MIL-STD-483(2).

Naming conventions for variables, constants, records, configuration items, components, routines, etc. shall be structured to improve readability and traceability. All computer software, support programs and data bases, and their associated documents developed for the given aircraft shall only be deliverable to the Government to comply with contract requirements. Computer programs delivered to the Government shall be in source and object code.

3.2.3.3.1.4 Computer Processor Utilization

The OBIGGS Controller shall receive a continuous stream of data from the aircraft and OBIGGS sensors. These inputs shall be compared to the pre-set program of optimum parameter values in a fault detection and monitoring algorithm and (if used) in a closed-loop, active feedback control system.

System status shall be displayed to the pilot on a digital display indicator or a caution word panel. The severity of the warning shall consider the fault's effect on Flight Safety, ability to complete the mission, and ability of the pilot of take corrective action.

3.2.3.4 Quality Factors

3.2.3.4.1 Reliability

Reliability program requirements shall be in accordance with MIL-STD-785B, using reliability terms defined in MIL-STD-721. The mature OBIGGS shall meet the reliability requirements herein while operating in the environmental conditions specified herein.

Mature OBIGGS availability, as determined from Maintenance Data Collection System, AFM66-1 analysis shall be 0.999. System MTBF shall be 149 hours as determined by AFM66-1 data analysis of the mature system.

Subystem minimum MTBF shall be as follows:

Air Separation Module	MTBF (MTBMA)
Solenoid Valve	25000
Crew Service Secondary Heat Exchanger	100000
	MTBF (MTBMA)
Water Extractor	50000
Air Separation Module	TBD
High Pressure Distribution	
Flow Control Valve	25000
Compressor, and Motor and Intercoolers	2000
High Pressure Bottle and Fittings	TBD
High Pressure Ground Service Connector	TBD
Orifice and Fittings	TBD
High Pressure Regulator	25000
Solenoid Shutoff Valve	25000
Manual Shutoff Valve	50000
Condensation Drain and Valve	20000
Check Valve	75000

Pressure Sensor	100000
02 Sensor	TBD
Flow Sensor	TBD
Controller/BIT	18000
High Pressure Relief Valve	TBD
Low Pressure Distribution	
Shutoff Valve	25000
Orifice and Fittings	TBD
Demand Regulator	TBD
Climb/Dive Valve	TBD
Scrub Nozzles and Fittings	200000
Check Valves	75000
IGG Supply Boost Compressor	
Boost Compressor and Electric Motor	20000
Trim Heat Exchange	100000
Temperature Sensor	300,000

3.2.3.4.2 Modifiability

3.2.3.4.2.1 Maintainability

Maintainability studies will be based upon sound, practical engineering judgement, experience, and available data. The OBIGGS shall be designed to require minimal maintenance, which shall consist of, and be limited to, performing only those tasks necessary for maintaining the OBIGGS in a safe, and properly operable condition. The system shall allow performance of organizational, intermediate, and depot maintenance.

The potential maintainability of the OBIGGS and its components shall be compared against the actual maintainability of existing hardware performing similar functions. Predictions for component Maintenance Man Hours per Flight Hour (mmh/fh) shall then be derived. The evaluation/comparison of similar, existing inerting systems, and the proposed OBIGGS shall be sufficient to afford a basis for determining realistic and meaningful requirements for follow-on programs. Maintainability program requirements and evaluation shall be in accordance with MIL-STD-470A and MIL-STD-471A, respectively.

3.2.3.4.3 Availability

The OBIGGS shall be available 99 percent of the time at the start of any mission.

3.2.3.4.4 Portability

The OBIGGS shall not employ system components which are unsuitable for normal transportation.

3.2.3.5 Logistics

3.2.3.5.1 Support Concept

Principles of supportability as described in MIL-STD-1388-1A will be considered at each progressive level of detail. The supportability program shall integrate reliability, maintainability, survivability, life cycle costs, and other logistics engineering areas. This shall be accomplished by incorporation of the appropriate tasks outlined in MIL-STD-1388-1A. The supportability analysis tasks shall be performed in an iterative basis. The design shall consider two levels of maintenance, on-equipment and off-equipment.

The OBIGGS, its subsystems, and components shall be designed to avoid the use of special maintenance skills, tools, and support equipment (SE). Common issue Air Force hand tools shall be used to support day-to-day maintenance at the main operating base as well as deployed locations.

The design shall be such that preventive maintenance tasks such as restoration of protective finishes can be accomplished on an as-needed basis. Scheduled inspections to ascertain the need for preventive maintenance measures shall not be required. Replacement of LRU's shall be accomplished on an impending or detected failure basis, rather than on a schedule or time controlled basis.

"On-condition" inspection, examination, and evaluation shall be utilized for determination of all maintenance actions. The OBIGGS shall be designed to minimize the number of LRU's and pieces of SE used for servicing, which must be procured and inventoried for rapid deployment

3.2.3.5.2 Support Facilities

All OBIGGS components will be designed such that they can be supported by existing facilities and equipment.

3.2.3.5.3 Supply

Demands on the supply system shall be minimized. Specific supply data shall be determined during system development.

3.2.3.5.4 Personnel

All OBIGGS equipment shall permit normally available maintenance personnel to safely, easily, and reliably perform all required preventive and corrective maintenance tasks on the flight line or at a depot under all anticipated test maintenance conditions. OBIGGS equipment maintenance functions shall not require the efforts of more than two men concurrently. Means shall be provided to facilitate the required maintenance functions including: 1) operational checkouts, 2) system malfunction detection, 3) Line Replaceable Unit (LRU) removal and replacement, 4) inspection, 5) servicing, 6) testing, and 7) access to the system and its components in order to accomplish the above.

Personnel requirements by speciality code and quantity shall be determined during system developement.

3.2.3.5.5 Training Requirements

Training for military maintenance personnel shall be determined during prototype development.

3.2.3.6 Precedence

In the event of conflict of requirements, requirements of this System Specification shall govern.

3.3 Qualification Requirements

3.3.1 General

3.3.1.1 Philosophy of Testing

The OBIGGS prototype shall be considered fully tested when it has performed to the requirements of this specification in a demonstration.

Quality assurance programs shall be established to identify, monitor and support prototype qualification testing. Testing shall be scheduled with sufficient lead time to allow adequate time for minor hardware configuration and performance adjusting resulting from refinement based upon a subjective concensus among test subjects evaluating the system. The period prior to flight demonstration shall be reserved for this purpose even if qualification testing is complete and compliance with system requirements have been demonstrated.

3.3.1.2 Location of Testing

The required configuration and qualification testing shall be accomplished at the contractor's facility. Flight qualification testing shall be accomplished at Edwards Air Force Base, California.

3.3.1.3 Responsibility for Tests

The contractor shall assume the responsibility for qualification tests for configuration and critical items.

3.3.1.4 Qualification Methods

Final system qualification shall be by analysis, demonstration and examination as detailed in the Prototype Development Plan.

3.3.1.5 Test Levels

All components shall be tested in accordance with the aircraft system's test plan.

3.3.2 Formal Tests

The contractor shall be responsible for all inspection and test requirements specified herein. Unless directed otherwise, the contractor shall use his own or any other suitable facility for the performance of the inspection requirements. Quality conformance inspections shall be required for all configuration items and critical items.

3.4 Preparation for Delivery

All equipment, assemblies, and parts developed for the ATF OBIGGS shall be marked for identification in accordance with MIL-STD-129H(4) and MIL-STD-130F(1). All fluid lines shall be marked in accordance with MIL-STD-1247B. Preservation, packaging, and packing shall be in accordance with MIL-STD-1188A, Level C, FED-STD-102B, PPP-B-636H(1), PPP-C-1752A(1), and PPP-B-6101F(2) as applicable.

Nameplates shall be permanently and legibly marked in accordance with MIL-STD-130F(1), MIL-P-6906B(1), MIL-P-15024D(1), and shall be securely attached to the OBIGGS hardware in locations where they can be read without removal of the hardware from the aircraft.

The current versions of AFR 300-10 standard higher-order programming languages shall be used in all systems of software development (JOVIAL -73 is preferred for embedded applications). Statements and subroutines written in non-standard code shall in all cases be clearly identified as non-standard code and shall, where possible, be separated from the standard code. Computer programs, regardless of media, shall be written using top-down structured programming techniques. Programs shall be structured using the computer program configuration item, and component definitions of MIL-STD-483(2).

Naming conventions for variables, constants, records, configuration items, components, routines, etc. shall be structured to improve readability and traceability. All computer software, support programs and data bases, and their associated documents developed for the given aircraft shall only be deliverable to the Government to comply with contract requirements. Computer programs delivered to the Government shall be in source and object code.

4.0 PROTOTYPE DEVELOPMENT PLAN

The prototype development plan for the best choice stored gas OBIGGS was based on a detailed work breakdown structure (WBS) that was divided into four major tasks: Preliminary Flight Design; Performance Analysis; Hardware Design, Fabrication, and Component Testing; and System Testing. Test requirements and test plan documents will also be completed upon delivery of the prototype system. A detailed description of the system test approach is contained in Section 4.1. A WBS outline and the development schedule are presented in Section 4.2. Figure 9 summarizes the program plan and Figure 10 shows the correlation between the major tasks to statement of work (SOW) paragraph numbers.

The fighter OBIGGS prototype development plan is time phased to the development of the prototype Advanced Tactical Fighter (ATF) airplane. The objective is to have a flight worthy OBIGGS developed in time for the ATF flight test program. Ground testing of the system will be conducted using the SAFTE facility at WPAFB. This will be completed in time for the prototype OBIGGS to be installed and flight tested on the prototype ATF. Key milestones of the OBIGGS development are shown relative to ATF milestones in Figure 11.

TASK 1 PRELIMINARY FLIGHT DESIGN

System Configuration Definition
Safety and Reliability Assessment
Critical Components Verified
Preliminary Design Review

TASK 2 HARDWARE, DESIGN, FABRICATION AND COMPONENT TESTING

Critical Components
Test Article Components
Test Support Hardware
CDR; Performance and Interface Document System
Test Article Assembly, Instrumentation and Checkout

TASK 3 SYSTEM TESTING

Test Requirements Document
Test Plan Document
Test Plan Review
Deliver Test Article To Test Site
Support Test

TASK 4 PERFORMANCE ANALYSIS

System Performance Analysis
Test Article Performance Analysis
Test Evaluation

DELIVER FINAL REPORT
CONDUCT CONTRACT FINAL REVIEW

Figure 9 OBIGGS Plan Summary

TASK	WBS	SOW
PRELIMINARY FLIGHT DESIGN	1.0	3.2
HARDWARE DESIGN, FABRICATION AND COMPONENT TESTING	2.0	3.5
Detail Design	2.1	3.5.2.2
	2.1.1	
	2.1.2	
	2.1.3	
Fabrication	2.2	3.5.1.1.2
	2.2.1	
	2.2.2	
	2.2.3	
Component Testing	2.3	3.5.2.1
	2.3.1	
	2.3.2	
SYSTEM TESTING	3.0	3.5.1.2
Test Requirements and Plans	3.1	3.5.1 2
	3.1.1	
	3.1.2	
	3.1.3	
Real-Time and Post-Test Support	3.2	3.5.2.1
	3.2.1	
	3.2.3	
	3.2.4	
PERFORMANCE ANALYSIS	4.0	3.5.2
	4.1	
	4.2	
	4.3	
	4.4	
	4.5	
	4.6	
	4.7	

Figure 10 Correlation Between WBS and SOW

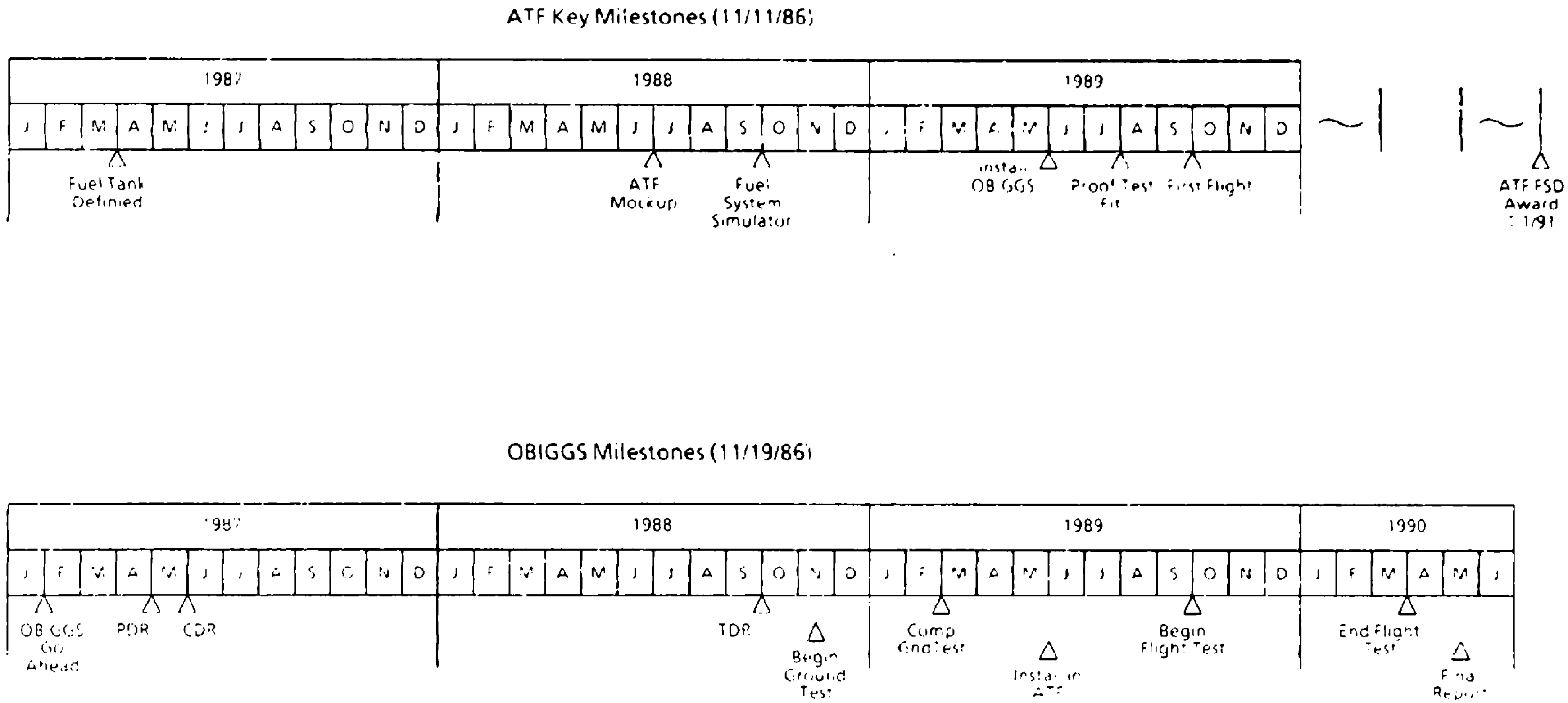

Figure 11. Prototype OBIGGS Program Major Milestones

Component specifications are presented in Section 3.0. These specifications will be used to identify components that can be procured off the shelf or upgraded to meet requirements with minimum risk. Interface control drawings will be issued for these components to ensure proper subsystem integration. Components that must be developed will be classified as critical components which must be individually designed to meet specification requirements. As yet, no component has been identified for the stored gas OBIGGS design which does not exist in at least a smaller version. For any critical components, design drawings will be prepared; engineering analyses will be performed; and parts, materials, and processes will be identified. Next, a system design effort will be initiated to produce layout assembly drawings; prepare subsystem power, weight, and volume data; and perform maintainability, safety, and reliability analyses. This information will be used to conduct a preliminary design review (PDR), during which the flight design, critical componen. identification, and preliminary requirements for a prototype system will be presented for AFWAL approval.

Following PDR, emphasis will shift to development of a system designed both for flight testing and interfacing with the SAFTE Fuel Tank Test facility at WPAFB.

The next major item will be a critical design review (CDR) that will be held at WPAFB. The detailed design drawings of the system and test support hardware will be presented together with critical component test results. SAFTE facility interface requirements for the system ground acceptance test and ATF interfaces for the flight tests will be discussed.

Following CDR approval, the test support hardware and the remaining system components will be fabricated. Component testing will be completed, and the correlated models will be incorporated into the final system performance model. The system will be assembled, instrumented, serviced, checked out, and shipped. Test plan test profiles will be defined and pretest predictions will be made. On-site support will be provided for the ground flight tests, including posttest evaluations, the results of which will be included in the final report. Delivery of the final report will conclude the program. The work breakdown structure (WBS), presented in Section 4, identifies those subtasks necessary to achieve task objectives described in this section. This expanded WBS is the basis for the program schedule. Also, the advanced stage of the baseline development study provides us with the data needed to move quickly into program tasks.

4.1 Technical Requirements and Approach

The technical approach for meeting the requirements of the four major tasks of the OBIGGS Prototype Development program are discussed in this section. Sections 4.2 through 4.6 contain information on specific task requirements, methods of approach, and benefits resulting from that approach.

Three fully developed, well-established, computer-based models will be used to generate realistic cost estimates during the development program (Appendix E). Experience in designing and testing helicopter OBIGGS hardware will provide valuable insight into production and test planning during this task. Previous contract work on related programs provides the background necessary to understand the need for a flexible approach in an environment of rapidly changing requirements.

4.1.1 System Design Criteria And Requirements

The point of departure for system design criteria and requirements will be the OBIGGS preliminary design presented in Volume I. A technical working session will be conducted at AFWAL as part of the kickoff and requirements review meeting to review this design and formally establish system and component requirements and interfaces. A draft requirements document will also be provided to AFWAL at this meeting.

Periodic reviews of system requirements will be needed. Therefore, reviews at the following key program milestones are recommended:

- The start of system detail design.
- The start of test plans and requirements development.

4.1.2 Maintenance, Reliability, and Safety

Maintenance, reliability, and safety are extremely vital factors that must be designed into the system as an integral part of each program step. For example, safety considerations dictate that in the event of failure, the subsystem will be designed to minimize the risk of damage to the aircraft. Design guidelines incorporating safety factors will be delineated for use during the program. These detailed guidelines and requirements will be developed from system safety hazards analyses, which will be performed by qualified safety engineers on an ongoing basis during the final design tasks. The same approach will be used for reliability and maintenance requirements. Analyses will be conducted as required to support engineering decisions. Systems safety analysis support will ensure that safety risks are identified and eliminated in the OBIGGS design and operational procedures. Preventing potential injury of personnel from ruptured ducts, compressor failure, and electrical components will also be a major consideration in the hardware design.

Boeing has an extensive experience base for reliability analysis of compressors pumps, valves, and similar components. As a result, evaluation of these items will be straightforward. During this program, any Boeing developed data that will contribute to improved solutions for these reliability issues as they affect the prototype OBIGGS will be made available to the program.

Primary goals for the OBIGGS design are to minimize maintenance and make the system easily maintainable. These goals will influence many of the design decisions made in developing the system.

4.1.3 Prototype Fabrication and Checkout

Fabrication and checkout of the OBIGGS prototype will occur over a 16-month period. Key features of this schedule are:

- o Purchase ordering of a long-lead items 12 weeks before assembly start.

- o Allocating sufficient time for system assembly and checkout, including thorough testing and debugging of mechanical, electrical, and control components, as required.

- o Preparing the system for delivery to the SAFTE fuel cell test facility and later to the ATF flight test program in test-ready condition. All instrumentation and test support equipment will be in place, ready to be connected to test facility components. This step, and our direct assistance with on-site integration of the system with the SAFTE testbed and later with the ATF will minimize the time and effort necessary to prepare for the final flight and acceptance tests.

Figure 12 illustrates the flow of parts and components and the assembly and checkout sequence.

Prototype components, will be obtained either from inhouse manufacturing capability or from scientific, aerospace, and commercial specialty manufacturers. The use of existing technology will have top priority in determining supply sources. Cost and availability will also be prime factors considered in make/buy decisions.

Boeing specialists will be used to review designs and prepare plans for quality assurance, reliability, safety, and material compatibility.

During this fabrication and checkout phase, quality assurance plans and design features will be included to ensure implementation of system safety and reliability. The project engineer will be responsible for implementing these plans and directing required specialized inspections and functional tests.

Specialists will conduct prototype assembly and checkout, including:

- o Skilled instrumentation and control system personnel with access to state-of-the-art aerospace-quality instrumentation and data processing facilities.

- o Engineers and mechanics with extensive experience in assembly, checkout, and sophisticated leak testing of aerospace-quality systems.

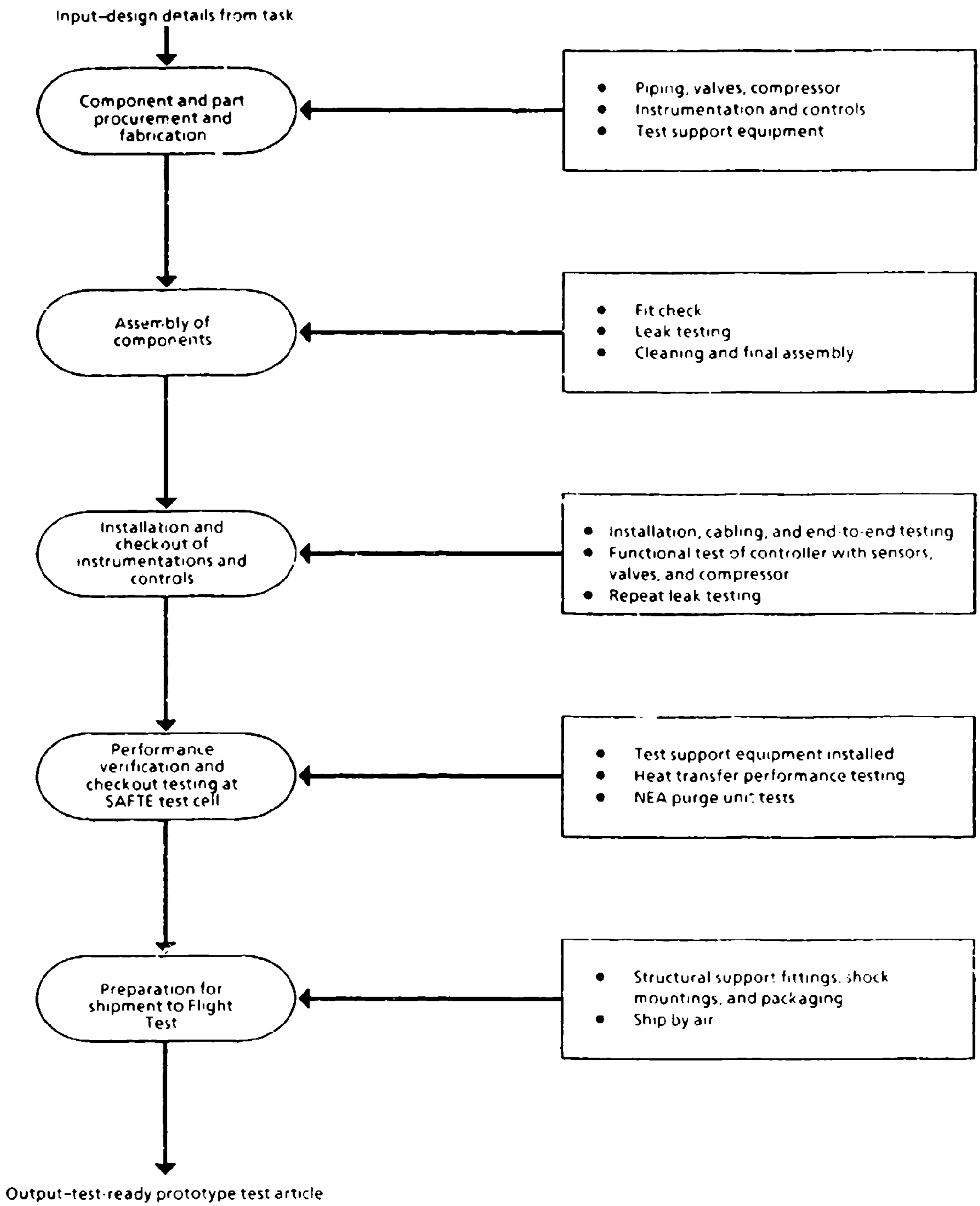

Figure 12. Assembly, Checkout, and Testing of System Test Article

Figure 13 lists the contents and sequence of functional checkout tests and inspection procedures to be completed before prototype delivery to ATF flight test. Performance will be verified for a range of typical operating conditions. The sequence of functional and checkout testing during unit assembly will maximize overall efficiency of these activities. Critical problems for the final assembly will be solved in stages.

All instrumentation will be verified after installation to ensure that data channel identification and actual sensor locations agree. The control system will be operated and verified by simulating sensor input signals and confirming that control responses are correct in location and direction of control of the compressors and valves. The performance verification and checkout testing specifications will ensure that system operating problems will be detected before the prototype is shipped to ATF Flight Test.

4.1.4 Prototype System Test

This section describes the prototype system test activities. These tasks and subtasks include defining test requirements, developing the detailed test plan, conducting the subsystem test, and documenting test results. Figure 14 is a workflow plan illustrating task inputs, subtasks, task outputs, and workflow relationships.

The prototype system test will be preceded by individual component tests to ensure that each component performs as specified. Problems revealed during the tests will be resolved before the prototype system is assembled. These tests will be conducted at Boeing, Seattle under direct control of the OBIGGS program manager. Therefore, component problems will be identified and resolved in a laboratory environment designed to perform these activities cost effectively. By performing these component tests, the risk of component performance anomalies occurring during the ground and flight acceptance tests will be minimized.

The complete system will be assembled, instrumented, and checked out before shipping it to the SAFTE test cell. Any problems will be identified and resolved at that time. The advantages of this approach are that it minimizes (1) the cost of identifying and resolving problems because all engineering and shop resources are available at our facilities and (2) the risk of test delays

Instrumentation and controls

- Sensor and cable end-to-end check for electrical and identity verification
- Simulted operation of controller, valves, and compressor

Alignment, leveling, and system integrity

- Optical alignment of parts
- Installation of special fittings for testing, shipping and handling

NEA purge tests

- Operate as required during initial startup of test article
- Operate through full range of anticipated demands
- Gradually build test levels to full design loads

Figure 13. SAFTE Ground Tests

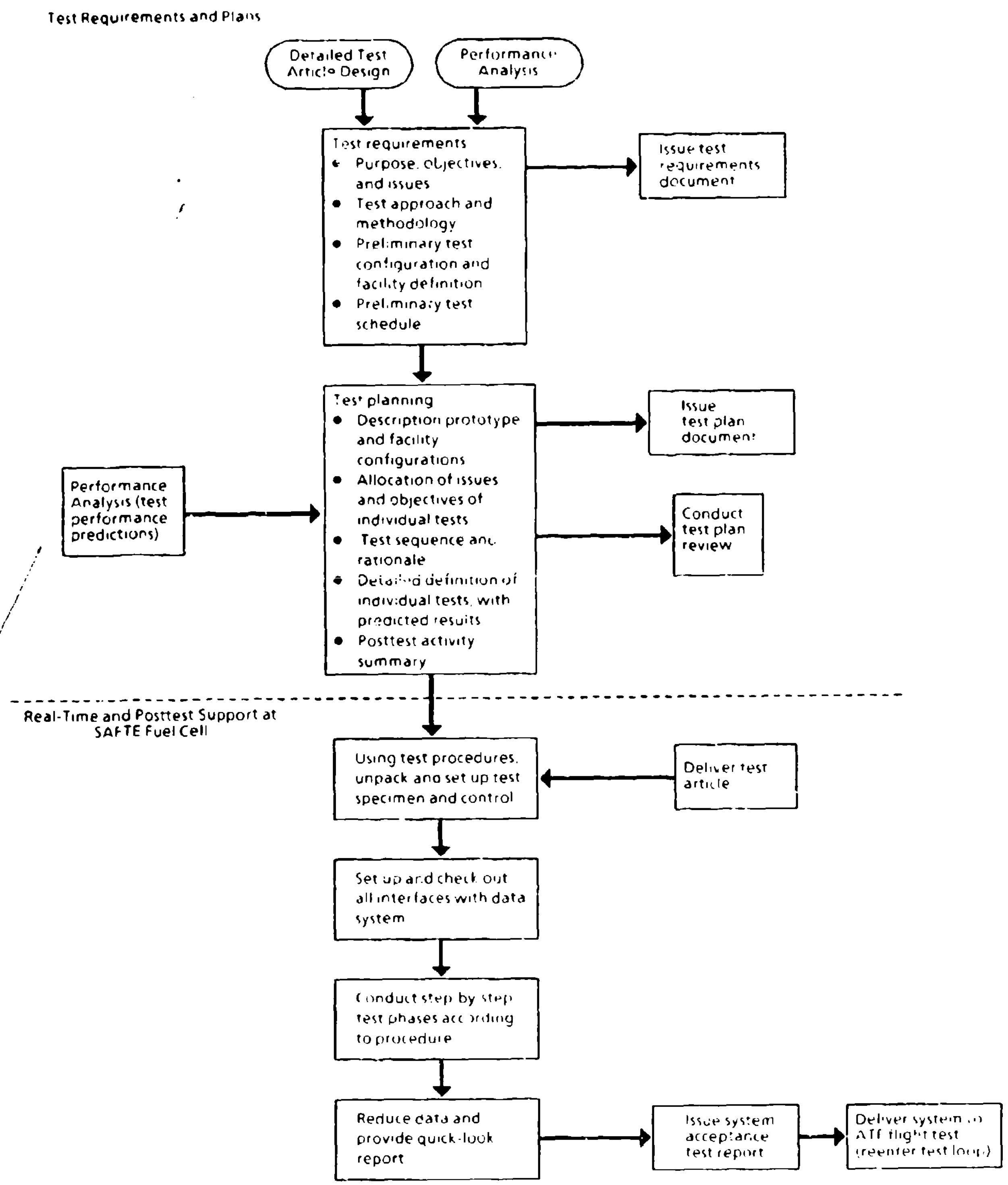

Figure 14. Test Program Logic Flow

during use of the testbed at AFWAL while problems are resolved. After successful completion of the checkout tests, we will ship the system, fully assembled and in working condition, to the SAFTE test fuel cell.

At month 19 in the program, all components will be fabricated and the test assembly will be starting. Therefore, the test article configuration will be finished making it possible to define the test requirements. The Test Requirements Document (TRD) will be released at the start of month 20. Preparation of the Test Plan Document (TPD) will begin when the TRD is released and will be complete 1 month later at the start of month 21. At this point, (1) the test support hardware fabrication will be completed, (2) the prototype system assembly will also be complete, and (3) analytical pretest predictions will be completed and documented. Because all hardware will be completed, the TPD can be developed without adding risk. Interface requirements will also be documented in time to support TRD preparation in month 20. Lastly, both the prototype system and the test support hardware will be at an advanced stage of development by the time the TRD and TPD are developed.

After the test documents are prepared and the system has been checked out, ground tests will be conducted at the SAFTE fuel cell testbed at Wright-Patterson AFB Ohio. The advantages of conducting these tests at WPAFB that (1) the tests will demonstrate that the system requirements have been met and (2) Boeing and Air Force personnel can familiarize themselves with system operation so that they can integrate and operate the OBIGGS during ATF flight tests.

4.1.5 Test Requirements and Planning

Test requirements will be defined by the personnel who perform the OBIGGS detailed design. They will use design information and the analytical models to produce the TRD. Using this information ensures that the personnel who develop the requirements are familiar with system details and are supported by correlated analytical models, which can simulate the full range of nominal and off-nominal operating conditions.

The TRD will be used to formalize test requirements so that the Boeing Propulsion Technology organization can develop the integrated test plan. The TRD will be submitted to AFWAL 1 month before start of the system ground test, which will be conducted at the SAFTE fuel cell facility. Figure 15 outlines the contents of the TRD, which will be prepared and submitted for AFWAL review.

1.0 BACKGROUND

1.1 Description of On-Demand OBIGGS Design

1.2 Mission Module Applications and Profiles

2.0 DESCRIPTION OF PROTOTYPE SYSTEM

3.0 SYSTEM ACCEPTANCE TEST PHILOSOPHY

3.1 Purpose

3.2 Objectives and Issues To be Resolved

3.3 Test Approach To Accomplish Objectives

4.0 PRELIMINARY TEST CONFIGURATION AND FACILITY REQUIREMENTS

4.1 Layout and Schematic Drawings

4.2 Interface Control Drawings

4.3 Boundary and Environmental Conditioning

4.4 Test Instrumentation and Controls

4.5 Data Acquisition, Processing, and Display

5.0 PRELIMINARY SCHEDULE OF TESTS

Figure 15 Test Requirements Document Contents

The TRD will describe the background, configuration, and preliminary purpose and objectives of the system acceptance test. The overall test philosophy and approach clarify how various test categories will meet the objective of verifying system interfaces and performance. The document will contain a system description and instrumentation and control requirements. Also included will be requirements for test support at the SAFTE fuel cell facility and at the ATF flight test site, including data acquisition, power requirements, interfaces, computer programs, and personnel responsibilities.

The test configuration and facility requirements will include schematic drawings of the test setup, including the test article, and test system controls. The document will include Interface Control Documents (ICD's) that define physical and electrical interfaces between the prototype and test support equipment.

A TPD, outlined in Figure 16, will be submitted 1 month prior to test start. The TPD will outline specifically how the test will be conducted and how the objectives and requirements will be met. The test plan will give final details of the test fixtures and interfaces, including how they are controlled during each test. The test plan will identify the location of sensors, describe the calibration variables, and the relationship of the sensors to the data acquisition system.

A test plan overview will relate specific test objectives and issues to specific tests. For example, the overall objective of verifying that OBIGGS performance satisfies design requirements will be part of the TRD. The additional detail provided in the test plan overview will specify exactly which steady state and transient tests will be conducted and which performance variables will be verified in each test or series of tests. This process is an allocation of objectives to individual and sequences of tests. This documentation will provide basic information to establish a preferred test sequence. Issues to be resolved in determining test sequence include (1) gradual development of maximum performance conditions, (2) controlled and monitored approach to test conditions that may be hazardous to equipment or personnel, (3) continuity of test condition changes to minimize time required to establish new fuel quantities or other conditions from one test to the next, and (4) subdivision of activities into testing sequences with clear objectives and results to provide convenient break points.

1.0 TEST CONFIGURATION AND FACILITY DESCRIPTION

1.1 Layout and Schematic Drawings

1.2 Interface Control Drawings

1.3 Boundary and Environmental Conditioning

1.4 Detailed Description of Instrumentation Channels

1.5 Detailed Description of Data Acquisition, Processing, Real Time Calculations, and Data Displays

2.0 TEST PLAN OVERVIEW

2.1 Individual Test Objectives and Issues to be Resolved

2.2 Allocation of Objectives to Individual and Sequences of Tests

2.3 Test Sequence and Rationale

3.0 DETAILED TEST PLANS FOR EACH TEST SERIES

3.1 Objectives

3.2 Test Conditions and Sequence of Events

3.3 Special Test Requirements

3.4 Predicted Performance and Anticipated Results

3.5 Correlation of Test Results with Objectives

4.0 POST TEST ACTIVITIES

4.1 Post test Inspections and Calibrations

4.2 Extended Data Processing

4.3 Contents, Quick-Look Test Report

4.4 Scope and Contents, Final Test Report

Figure 16 Test Plan Document Contents

Another important element of the test plan will be documenting predicted results for critical tests. These predictions will be used to confirm normal operation during conduct. This step will aid in early detection and resolution of any problems with the test setup, instrumentation, or prototype system, and minimize response time to any unexpected test errors or problems.

The TRD will contain a complete test matrix and step-by-step directions for the conduct of each test.

4.1.6 Real-Time and Post Test Support

The OBIGGS prototype will be delivered fully assembled and ready for acceptance testing to the SAFTE test cell in month 20 and to ATF flight test in month 28. Before it is shipped, the system will have successfully passed checkout tests verifying system performance. This test support equipment will be delivered with the system for use at the test facilities. All physical, electrical, and instrumentation interfaces will have been coordinated with AFWAL and documented so that both the system and the test support equipment will be fully compatible with the fuel cell test bed facility and the ATF.

During the pretest and checkout activities at the SAFTE fuel cell, two test engineers will coordinate interfacing the system with laboratory facilities and test support equipment. This list will be reviewed during the program and completed during the test requirements definition phase. If any of the required equipment is not available at the test sites, it will be supplied from general purpose test equipment inventory and shipped with the system. This will minimize the cost to conduct the system acceptance test.

During testing, two engineers will support the test so that at least one engineer is available 24 hours per day. These engineers will provide onsite consultation to test personnel, assist in taking data, make real-time decisions, and assist in troubleshooting hardware anomalies. Their availability reduces the risk of schedule slides during the tests.

A quick-look test report will be prepared two weeks after completion of the ground tests and after the flight tests. Two weeks after the final flight test, a final performance and evaluation report will be prepared. This report will present the test data and compare them with analytical pretest predictions and requirements established in the early phases of the program. Anomalies will be analyzed and evaluated in terms of their significance and impact on system and subsystem performance. In addition, performance deficiencies will be noted and recommendations made for their correction based on previous design, analysis, and test experience.

4.2 Program Management Plan

The Boeing management approach to the OBIGGS Development program will emphasize early risk detection and resolution and the economic allocation of skilled personnel to ensure program completion on time and within budget. Recognizing the value of communication regular meetings have been incorporated into the schedule to resolve technical issues and provide data on program progress. The program plan is shown in Figure 9, the logic network in Figure 14, the WBS and the program schedule in this Section. Individual task flow charts for Tasks 1 through 4 in Section 4.0 identify how we will conduct these major tasks to achieve our technical objective. The program management plan describes how the staffing and resource allocation will ensure that the fluctuating needs for specialized personnel and facilities are met.

Major program milestones include preliminary design review, critical design review, hardware fabrication, and acceptance tests. The program plan will utilize highly specialized personnel and to use production and test facilities for only the limited times they are required. These engineering and laboratory resources will be drawn from within the Propulsion Technology organization and phased into and out of the program development as required. The management approach is designed to respond to short-term assignment needs and changing skill mix requirements.

To conduct this program, Boeing will assign management and technical personnel who have the expertise and experience in fuel tank fire supressant research development management, design and analysis.

The program manager will have total responsibility for meeting program cost, schedule, and technical requirements. He will also be the single point of contract with the AFWAL Contract Monitor/Project Engineer for technical and program overview and direction. The program organization is detailed in Section 4.2.7.

Support organizations will provide the program manager with a team of contract and cost accounting specialists to ensure timely and complete contract compliance. This team will administer the contract, establish and maintain communication with the Air Force Contract Officer/Technical Representative, and provide cost and schedule visibility within Boeing to ensure a successful program.

The Contracts organization is responsible for all Boeing Military Aircraft Company research and development contracts except for major programs requiring dedicated contract organizations. To support the OBIGGS Development program, Contracts will:

- o Establish and maintain communication between Boeing and AFWAL.
- o Monitor and coordinate delivery of all contractually required deliverable items.

The program manager will maintain surveillance of milestone performance versus expenditure to detect and report any deviations that might affect program status.

The Finance organization will administer a cost collection and monitoring system that provides the program manager with the visibility needed to accurately monitor planned versus actual program expenditures. Costs, including labor, nonlabor, and overhead will be collected at a tier II (task) level and will be published weekly. At contract award, the program manager will review program manloading and scheduling with Finance, and Finance will prepare a complete spending plan. Engineering assignments and commitments for the duration of the program will be based on this expenditure plan.

Finance will collect actual expenditures through the Boeing program cost report system. The current and cumulative expenditures and planned levels will be published weekly as computer printouts, which will include engineering and computer cost totals for the current week, month, and program to date. Associated dollar expenditures, including labor rates and overhead burden, will also be shown. By-name data will allow the program manager to identify the labor and dollar level being expended by each individual assigned to the program. With this information, the program manager can properly monitor and control program expenditures.

The Materiel organization monitors subcontractor and supplier performance. When buying from suppliers, Materiel, under the direction of the program manager, establishes equipment and material requirements, seeks bids, orders material, and monitors delivery compliance.

The overall program plan will ensure on-time completion of program objectives that include detail design fabrication and components testing, and system testing. This program plan will be coordinated with AFWAL and defined further during the first month of program performance and presented for approval at the requirements review conducted two weeks after contract award. AFWAL comments will then be incorporated and the plan delivered to AFWAL 1 month after contract go-ahead. Figure 3 illustrates the key features of our program plan, listing the critical components relating to key technical issues. Identifying these components early in the program will allow early design, fabrication, and test, allowing resolution of sensitive issues such as compressor reliability. This early consideration of critical components will greatly reduce schedule risk.

Preparation of requirements and test plans also will be supported by analytical models. This will aid in the selection of test points, sensor locations, and measurement ranges at the sensor locations.

Additional details of our program management plan are presented in this Section. In summary, the management approach will provide:

- An experienced program manager who directs a large, experienced staff.
- Frequent coordination with AFWAL early in the program to ensure that we address all of the technical objectives.
- A hardware development program structured to include designers and analysts to minimize technical, cost, and schedule risks.
- The expertise of personnel from a wide range of technical specialities.

4.2.1 Conference Requirements

Formal reviews with AFWAL are necessary and desirable for achieving program technical objectives on time. These reviews will provide for technical interchange between the program team and AFWAL for technical direction from AFWAL. A minimum of 13 formal reviews are planned, and will be supported by Boeing at AFWAL as listed in Figure 17.

The requirements definition review will occur two weeks after contract award. At this time, our principal investigator will meet with AFWAL to formalize design criteria and requirements. Mutually agreed-to requirements and criteria must be established early in the program because a clear understanding of these requirements is necessary for carrying out subsequent tasks.

A data package will be prepared and delivered to AFWAL for review two weeks before the PDR, which will be three months after contract award. At this meeting, the flight prototype configuration will be presented and technical direction from AFWAL and approval of the configuration will be recieved before proceeding. A PDR report will be prepared and distributed two weeks after the review.

A CDR data package and a performance and interface package will be prepared and distributed to AFWAL for review two weeks before the CDR. The CDR will occur four months after contract award. At this time, the detailed design of the OLIGGS flight system will be presented. Analytical performance predictions for the individual components and the system will also be presented. At this review, technical direction and approval of the detail design will be received before proceeding with final hardware fabrication. A CDR report will be prepared and distributed two weeks after the review.

Review	Months After Contract Award
Requirements Definition	0.5
Preliminary Design	4
Critical Design	5
Program Status	8, 12, 16, 19, 24, 28, 32, 36
Safety	6
Final Report	39

Figure 17 Formal Reviews at AFWAL

PROGRAM STATUS REVIEW

Program Status Reviews will be scheduled at generally four month intervals. The reviews will take place at AFWAL. A performance report will be prepared and presented to AFWAL two weeks prior to each review. At AFWAL discretion any scheduled review can be cancelled if the performance report alone provides program update information in sufficient detail to satisfy AFWAL for that period.

At certain points in the program it may be desirable to hold informal reviews with AFWAL at our facility; for example, during component tests. These reviews will be arranged with AFWAL as appropriate.

4.2.2 Configuration Management Requirements

Interface control drawings will be used to ensure that components interface properly with hardware supplied by the subcontractor, associate contractor, and customer. Procurement specifications will ensure that components purchased from suppliers will perform as required. These configuration management techniques will be applied, as appropriate, during the detailed design task.

4.2.3 Contractor Data Management

We will use our data management functions to manage SOW-required data. The Propulsion Technology organization, under the direction of the program manager, will be responsible for the collection, preparation, publication, quality, and assessment of all data contained in the data requirements list.

Document numbers will be assigned to all formal reports created during the program. A release date will be assigned to each document when the number is assigned. The Data Management and Contracts organizations will monitor document preparation to ensure on-schedule completion. Once the document has been prepared and approved, Data Management will be responsible for all further data management functions, including release, distribution, maintenance, and recall.

4.2.4 Documentation Requirements

This section describes the documentation to be furnished to AFWAL during the program. Section 4.4.1 discusses contract deliverable data items, which are summarized in Section 4.4.2. Major reports and documents are shown on the program schedule (Figure 17).

4.2.4.1 General

All reports and documents listed in Figure 11 will be provided. These reports will be prepared according to the appropriate data requirements description (DRD). In addition to the reports and documents listed in Section 4.4.2, a quick-look test summary two weeks after completing the ground and flight test will be provided. Internal documentation such as activity reports and weekly program management reviews will be used as program management tools. Excerpts from these internal documents will be used whenever possible to meet or supplement documentation requirements and thus minimize costs.

The detailed program plan will be submitted to AFWAL at the end of the first month of contract performance and will serve as the master plan and schedule used to conduct the program. It will contain a detailed work breakdown structure (WBS) and a schedule with all major milestones, decision, points, and actions. The plan shows program organization and lines of responsibility. Key personnel from program management, safety, reliability, quality assurance, systems engineering, development, production, and product support organizations will be identified by name. The plan will detail how key personnel will conduct the various program tasks.

The PDR and CDR data packages, discussed in Section 4.1, will be submitted to AFWAL 2 weeks before their respective reviews. The performance and interface document will define the OBIGGS mechanical and electrical interfaces. The interface document will provide the data required by the integration contractors to do their design and packaging work. This document will be submitted with the CDR data package.

A detailed test plan will be submitted to the Air Force for approval prior to the start of testing. The test plan will contain a complete description of the test requirements, including system development background, test hardware description, objectives, categories, and hardware preparation requirements, instrumenation and data acquisition requirements, facility requirements, and hardware lists.

Two weeks before starting testing, an integrated test plan document will be submitted to the Air Force. This plan will give the overall approach to meeting the requirements outlined in the test requirements document (TRD). The plan will contain details of instrumentation, data acquisition, real-time data processing, posttest data reduction, setup, and profiles for the prototype system acceptance tests. Also contained in the test plan will be a complete set of hardware performance predictions for each test point to be run.

A quick-look data report will be provided two weeks after completion of the ground and flight tests. This report will discuss the real-time data taken during the tests, the test setup, the test points, data, objectives, requirements, and to what extent the requirements were accomplished. In the report we will recommend corrections for any observed performance deficiencies. The final performance and evaluation report will summarize program quality assurance, reliability, and safety.

Monthly progress report will be submitted to the Air Force at the end of each month of performance. Each report will discuss the technical progress made during the month and the work planned for the following month, including the results of analyses, design trades, assessments, and verifications. Problems and proposed solutions will also be discussed in the monthly reports.

In addition to technical progress, the monthly reports will show cost, manpower, and schedule status. The cost and manpower will be reported to a tier II (task) level.

4.2.4.2 Data Requirements List

All the documentation listed in Figure 18 will be provided. These reports will provide the Air Force with the information needed for program management, control, and technical evaluation. In addition, prototype test hardware will be delivered to the Air Force.

4.2.5 Interface Requirements

This section describes how the OBIGGS interface requirements will be handled during the prototype development program. The key interface requirements for our baseline concept are presented in the OBIGGS system specification (Section 3). The design data packages and the final evaluation report will describe the interfaces. The descriptions will contain sketches, charts, drawings, and technical narration in enough detail to enable the Air Force or their appointed representative to incorporate the prototype OBIGGS into their systems.

4.2.6 Program Schedule

The program schedule includes progress reviews and completion dates for all tasks. Figure 19 shows the program master schedule, including the major tasks and milestones.

Task 1, Preliminary Design, and Task 4, Performance Analysis, will begin simultaneously. The configuration definition will be completed in time for PDR at the end of month 3. The performance analysis will begin in month 4 and continue through the end of the flight testing. Computer usage, initially high while the performance models were being built and checked, will be reduced after final design decisions have been made. Computer usage will again increase to support pretest performance predictions and final post test subsystem performance evaluations. After the test components are modeled, the performance modeling level of effort will be part time until month 16, when subsystem performance predictions will be initiated. Performance analysis and model documentation will be delivered following flight test.

Task 2, Hardware Design, Fabrication, and Component Testing, will begin on completion of PDR. This task will be concurrent with Task 4, Performance Analysis, because information from these two tasks will be used in the detail design process. Detail design will be completed in time for the CDR at the end of month 4. The critical component tests, which will start in month 6, will be completed at the end of month 9. Those components tests required for basic component selection will be done early to support detail design. Fabrication will be completed in month 19, when subsystem assembly and checkout will begin at BMAC Seattle. After checkout tests are completed, the test article will be shipped to WPAFB for ground tests beginning at the start of month 22.

Description	Sequence	Schedule*
Program Plan	DRL 1	1 MAC
PD Report/CD Report	DRL 2	2 Weeks after each review
Program Status Report	DRL 3	#MAC and at 4 month intervals thereafter
Test Requirements Document	DRL 4	20 MAC
Test Plan Document	DRL 5	21 MAC
System Acceptance Test and Final Performance Report	DRL 6	40 MAC
Monthly Progress Report	DRL 7	10 days of following month of each contract performance
Shipping Document	DRL 8	Within 10 days of each DRL release
Technical Information Release	DRL 9	4 weeks prior to each release
Document Charge Notice	DRL 10	As required
Performance Management	DRL 11	With each monthly progress report 10 days following each month of contract performance

* MAC: Months after contract go-ahead

Figure 18. Data Requirements List and Delivery Schedule

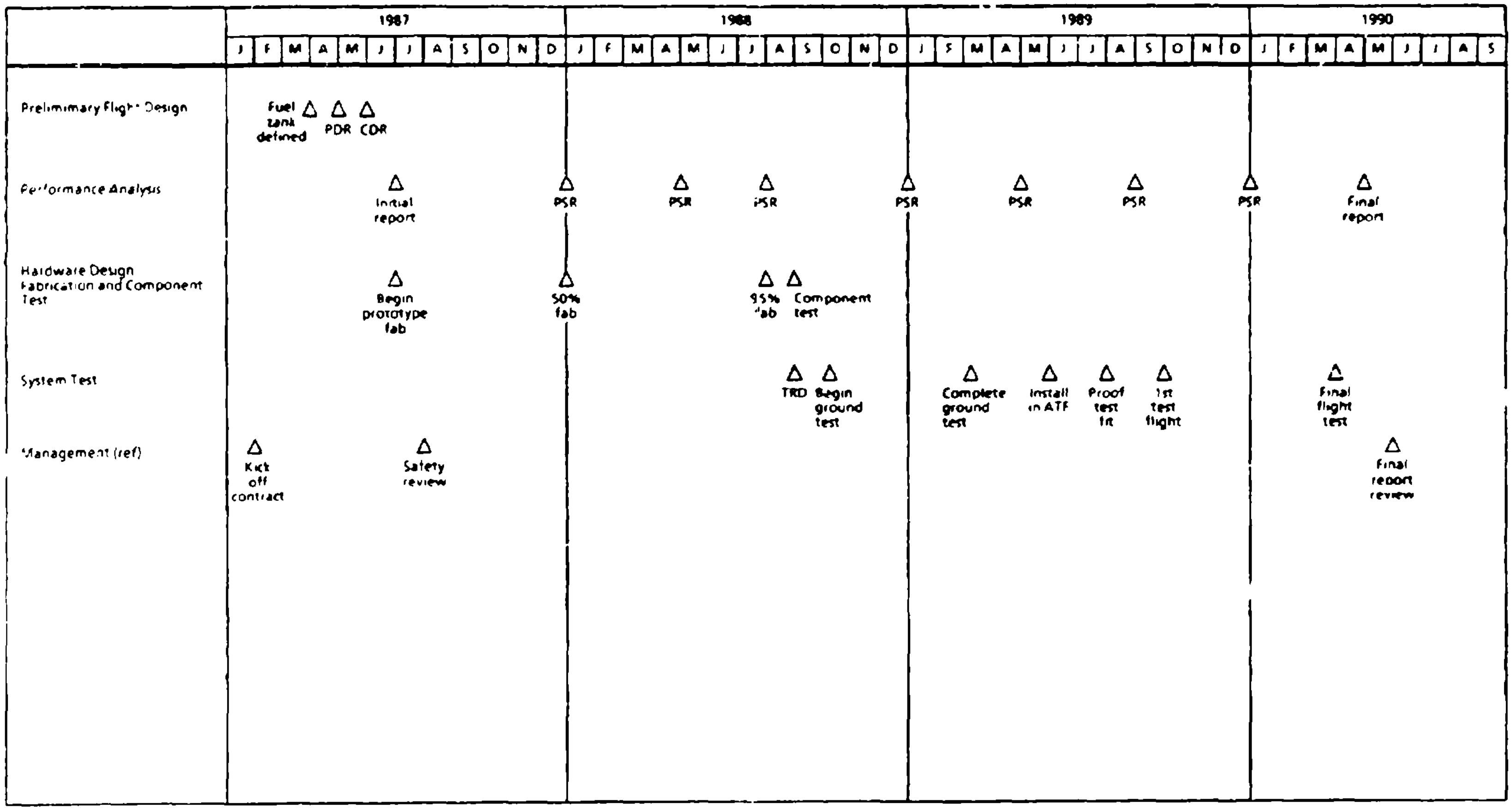

Figure 19. Program Master Schedule

System Testing, will begin at the start of month 20 and be completed, ground and flight 18 months later. The test report will be sent to the Air Force during month 38 and the final review held at WPAFB at the end of month 39.

Figure 19 demonstrates the planning for effectively managing the completing this program on schedule.

4.2.7 Program Organization

The OBIGGS prototype developed will be managed by the Boeing Military Airplane Company (BMAC). The development will be fully supported by BMAC using internal or external resources as required. Details on personnel assignments, person hour breakdowns and subcontracting, GFE and travel plans will be supplied when program finding is clarified. As stated in the life cycle cost study (Section 2) the estimated price of prototype development was $15M. The price could vary of course depending on the level of development of components and the total system and level of ground testing.

4.3 Quality Assurance

The Quality Assurance organization will appropriately apply MIL-Q-9858A to this developmental fabrication support program to cost-effectively meet all contractual quality assurance requirements. There is a one-to-one correspondence between primary areas of MIL-Q-9858A and our quality assurance manual, thus ensuring compliance with contractual quality assurance.

Quality Assurance is responsible for maintaining the Metrology organization, a three-level, companywide measurement control system. The highest level (Class A) includes primary measurements standards and is in our metrology laboratory. The second level (Class B) represents working standards, and the third level (Class C) measures product attributes at the hardware level.

The environmentally controlled Class B laboratory is at the Kent Space Center. Class B standards are checked periodically against Class A primary standards; Class A standards are referenced against those maintained by the National Bureau of Standards.

The OBIGGS program will emphasize, in particular, quality assurance as an integral part of the design process. Three examples of this are in materials compatibility, ground testability, and component interface requirements. The Quality Assurance organization will be responsible for ensuring that all materials specified on the fabrication drawings are on appropriate lists.

Quality assurance will participate from the design tasks through fabrication, checkout, and test. Scheduled component tests will identify and resolve problems with component performance before the components are assembled into the system. Finally, the entire assembly will be checked for adequate performance before it is shipped for acceptance tests.

Our final report will summarize these and other quality assurance efforts.

4.4 Prototype Reliability and Maintainability

4.4.1 Reliability Program

No dedicated R&M testing will be conducted; R&M will be evaluated during each test. The final evaluation will be based on the aggregate results for the entire test program. The reliability program will be planned in accordance with MIL-STD-785B. Tasks 101, 102, 104, 202, 204, 208, 209 and 303 and the maintainability program in accordance with MIL-STD-470A. Tasks 101, 102, 203, 204, 205 and 206. The Tasks of each MIL-STD will be tailored to meet program objectives. The test program techniques, duration and analysis follows.

The reliability program will address the following:

- o Control of Subcontractors through Mean Time Between Failure (MTBF) requirements, acceptance criteria, and monitoring the successful completion of their reliability activities. The extent of each subcontractor/supplier reliability program will be determined by the complexity and/or criticality of the item being procured.

- o An OBIGGS reliability mathematical model will be developed. Reliability predictions will be made for new equipment and those with extensive modifications. These estimates will be incorporated into existing estimates for items undergoing no change.

- o Success/failure data will be collected from AFR 66-1 and Navy 3M historical operational data, subcontractors and other related projects. The results will be analyzed, documented and reported. Failures will be subject to failure analysis and corrective action recommended to prevent recurrence.

- o Reliability engineering will present the analysis in support of program design reviews. The Reliability Test Plan will describe the methodology, scheduling, responsibilities, facilities, environmental profiles, test procedures and reporting requirements of any dedicated reliability tests. Reliability testing will consist of Test, Analyze, and Fix (TAF) testing, Fixed Length Reliability Testing (FLRT), and burn-in. TAF and FLRT will be performed at the Line Replaceable Unit (LRU) level on new and modified hardware identified in the system Specification. The number of units to be tested will be a function of the FLRT test selected from MIL-STD-781C. The TAF test will consist of a series of simultaneous vibration and temperature cycles during which the hardware under test will be operated and monitored for failure. Following the TAF test, a FLRT will be conducted utilizing thermal and vibration conditions selected to be representative of operational service during a typical mission. The FLRT hardware will be the same types and quantities used in the TAF. Corrective action recommendations for all pattern failures will be provided. Areas where fixes may be appropriate will be identified based on analysis of FLRT failures and the group level MTBF calculated from FLRT operating time and failure data.

TAF testing will provide engineering information on failure modes and mechanisms of hardware under natural and induced environmentally severe conditions anticipated during normal military service. FLRT will simulate normal operational conditions and will provide an assessment of equipment reliability. The objective of the TAF/FLRT Program will be accomplished by defining corrective actions which will lead to increased reliability in the production hardware. Hardware commonality with previous burn-in program requirements will be practiced in the interest of cost-effectiveness.

4.4.2 Maintainability Program

The maintainability program will be in accordance with applicable guidelines of MIL-STD-470A. The program will include the following elements:

- o Perform a maintainability analysis for the selected OBIGGS system.
- o Establish Maintainability Design Criteria, Mean Time to Repair (MTTR), and maintenance task times.
- o Incorporate Maintainability Requirements in Subcontractor Specifications. Quantitative and qualitative maintainability requirements will be included in specifications for subcontractor items.
- o Participate in Design Reviews. Maintainability requirements will be evaluated during Program Design Review (PDR) and Critical Design Review (CDR) to verify that designs have satisfied all maintainability requirements.
- o Establish Data Collection Analysis and Corrective Action System. Data collected from hardware design reviews and in-test use will be analyzed against maintainability design criteria. Corrective action will include redesign and reallocation of requirements as appropriate.

4.4.3 Vendor Testing Requirements

Reliability and Maintainability (R&M) test requirements will be required of subcontractors/vendors. Those requirements will be included in subcontractor specifications. Verification of R&M requirements will be accomplished by analysis and critical item testing monitored by the contractor and the customer.

4.5 Facilities

Tasks of this program will be carried out at BMAC-Seattle. Task 3, the System acceptance test, will use the SAFTE test cell and the AFT. This section describes all Boeing and Air Force owned facilities required for program completion.

4.5.1 Production and Test Facilities

Boeing maintains extensive manufacturing facilities to support production line fabrication of hundreds of identical components as sell as one-of-a-kind development projects for our technology organizations. In addition to conventional sheet metal, machine ship, and welding equipment, Boeing has the latest in numerically controlled machine tools, electron beam welders, brazing furnaces, tube bending equipment, electron discharge machines, and complete heat treating and surface coating equipment. Personnel who operate these machines are supported at the manufacturing level by technical and administrative personnel who provide scheduling and planning necessary to meet program schedules. These facilities will be used as required to accomplish the tasks in this program.

Diverse laboratories are maintained to support development and production programs. Included are laboratories that can conduct material evaluations, electronics tests, flow tests, closed loop ECS tests, synthetic materials development, electronic systems development, and evaluation and development of welding processes. Technical personnel in Quality Control can provide consultation for development programs.

4.5.2 Computing Facilities

Boeing computer facilities will be used to perform all analyses. Boeing has available to the program over $100 million worth of computers, including IBM 3033's and 3032's, Cyber-174's, SDS 8300's, and Cray-1's, along with VAX 11/780 systems, peripheral equipment, and qualified support personnel.

An extensive software library is also available to this program for OBIGGS trade-off studies and ECS analysis and design.

4.5.3 Government-Furnished Facilities

Government furnished special test equipment will be required only to complete system testing of the prototype OBIGGS at the SAFTE testcell facility.

Government-furnished equipment required for testing will be listed generically in the test requirements document and will be coordinated with the Air Force so that we can specify existing equipment to the maximum extent possible. The final detailed descriptions of test equipment required for system tests will be provided in the test plan document.

5.0 CONCLUSIONS

5.1 Life Cycle Costs

Detailed life cycle cost comparisons were made for five aircraft fuel tank fire protection systems: liquid nitrogen, Halon, explosion suppressant foam and stored gas and demand OBIGGS. Where possible, cost factors were based on field experience. For systems still in the development phase, the cost factors were based on the best available estimates and projections.

The results revealed that the OBIGGS concepts were the least costly alternatives compared with other aircraft fire protection systems on a life cycle cost basis. This is significant because the many advantages offered by OBIGGS for fuel tank fire protection are supported by lower life cycle costs.

5.2 Specifications

Detailed specifications for the "best choice" OBIGGS presented in Volume I were developed. Since the "best choice" OBIGGS was a stored gas system, the specification included a high pressure compressor and storage bottles in addition to more conventional items such as ECS equipment fuel scrub nozzles. Since the preliminary design was quite complete and Boeing has excellent background of aircraft and OBIGGS experience a quite complete set of specifications were established.

5.3 Prototype Development Plan

The prototype development plan provides details on the mechanism for transforming the current OBIGGS preliminary designs into a flight worthy system. The plan is time phased with the development of the ATF airplane, since the prototype ATF appears to be a good test bed for fighter OBIGGS flight testing.

LIST OF ABBREVIATIONS AND ACRONYMS

AFLC	Air Force Logistics Command
AFM	Air Force Manual
AFR	Air Force Regulation
AGE	Aerospace Ground Equipment
ASM	Air Separation Module
ATA	Advanced Technology Aircraft
ATF	Advanced Tactical Fighter
BF	Before Flight
BIT	Built-In Test
BTF	Between Flight
CD	Chemical Defense
CDR	Critical Design Review
CRM	Contract Responsibility Matrix
CWBS	Contract Work Breakdown Structure
dB	Decibel
DDI	Digital Display Indicator
ECS	Environmental Control System
EMC	Electromagnetic Compatability
EMI	Electromagnetic Interface
E3	Electromagentic Environmental Effects
fh	Flight Hour
FLA	Flight Line AGE
FLRT	Fixed Length Reliability Testing
FSD	Full Scale Development
gr	grains (of water; 7000 grains = 1 lbm)
h	Altitude
H	Specific Humidity
HEI	High Eneergy Incindiary
HP	High Pressure
ICD	Interface Control Document
IF	In Flight
IGG	Inert Gas Generator
INS	Inspection
LCC	Life Cycle Cost
LEMP	Lightning Electromagnetic Pulse
LN_2	Liquid Nitrogen

LIST OF ABBREVIATIONS AND ACRONYMS (continued)

LRU	Line Replaceable Unit
LSC	Logistics Support Cost
mmh	maintenance manhour
MEAC	Management Estimate at Completion
MODAS	Maintenance and Operational Data Access System
MSIGG	Molecular Sieve Inert Gas Generator
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
MTBMA	Mean Time Between Maintenance Actions
MTTR	Mean Time To Repair
NBC	Nculear/Biological/Chemical
NEA	Nitrogen Enriched Air
NEMP	Nuclear Electromagnetic Pulse
NIU	Nitrogen Inerting Unit
NRTS	Not Reparable This Station
$\%O_2$	Oxygen Concentration (percent by volume)
O&S	Operating and Support
OBIGGS	On-Board Inert Gas Generation System
OBOGS	On-Board Oxygen Generating System
ppm	parts per million
PD	Preliminary Design
PDR	Preliminary Design Review
PFFH	Peak Force Flying Hours
PMIGG	Permeable Membrane Inert Gas Generator
PRICE-H	Program Review of Information for Costing and Evaluation-Hardware
PSR	Program Status Review
RDT&E	Research, Development, Test and Evaluation
R&M	Reliability and Maintainability
rms	Root Mean Square
RTS	Reparable This Station
sat	Saturation
SAFTE	Simulated Aircraft Fuel Tank Environment
scfm	standard cubic feet per minute
SE	Support Equipment
SON	Statement of Need
TAF	Test, Analyze and Fix

LIST OF ABBREVIATIONS AND ACRONYMS (concluded)

TBD	To-Be-Determined
TFFH	Total Force Flying Hours
TPO	Test Plan Document
TRD	Test Requirements Document
VAC	volts, alternating current
VDC	volts, direct current
WBS	Work Breakdown Structure
WI	Calculated Inert Product Gas Mass Flow
W_o	Calculated Supply Air Mass Flow
WUC	Work Unit Code
3M	Maintenance and Materiel Management
μ	micron

APPENDIX A

RCA PRICE H INPUTS

The following pages show the input format for the RCA PRICE H model and the inputs used in the OBIGGS life cycle cost studies.

PRICE Input Data Worksheet

Basic Modes

File name: ______
Sheet ___ of ______

Title:

Date:

General A	Production Quantity QTY	Prototypes PROTOS	Weight (lbs) WT	Volume (ft^3) VOL	Mode. HW/SW Integration MODE . HSINT	
General B	Quantity/Next Higher Assembly QTYNHA	NHA Integration Factors Electronic INTEGE	Structural INTEGS	Specification Level PLTFM	Year of Economics YRECON	Year of Technology YRTECH
Mechanical/ Structural	Structure Weight WS	Manufacturing Complexity MCPLXS	New Structure NEWST	Design Repeat DESRPS	Mechanical Reliability MREL	
Electronics	WE Per Ft^3 / Volume Fraction WECF / USEVOL	Manufacturing Complexity MCPLXE	New Electronics NEWEL	Design Repeat DESRPE	Electronic Reliability EREL	
Development	Development Start DSTART	1st Prototype Complete DFPRO	Development Complete DLPRO	Engineering Complexity ECMPLX	Tooling & Test Equip. DTLGTS	Prototype Activity PRCSUP
Production	Production Start PSTART	First Article Delivery PFAD	Production Complete PEND	PRICE Improvement Factor PIF	Tooling & Test Equip. PTLGTS	Rate/Month Tooling RATOOL
Actual Cost Data (Mode 7 only)	Average Unit AUCOST	Production Total PTCOST	Prototypes PRCOST	Development Total DTCOST		

Notes:

1 ELECTRONIC ITEM
2 MECHANICAL ITEM
6 MODIFIED ITEM
7 ECIRP

GC 1613 1/85

RCA

Figure IV-1. PRICE Input Data Worksheet, Basic Modes

```
PRE COOLER
750 20 14 .3646 2
1 0.0 0.3 1.8 0785
14 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PRESSURE REGULATOR
750 20 4 .0174 2
1 0.0 .3 1.8 0785
4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CREW SERVO PRIMARY HEAT EXCHANGER
750 20 11 .3646 2
1 0 .3 1.8 0785
11 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PRE COOLER TEMPERATURE CONTROL VALVE
750 20 3.5 .0174 2
1 0 .3 1.8 0785
3.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
TEMPERATURE SENSOR
750 20 .2 .0006 2
1. 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
DUCTING
750 20 26.4 .3912 2
1 0 .3 1.8 0785
26.4 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
WIRING & MISL
750 20 6.5 .0975 2
1 0 0.3 1.8 0785
6.5 5.7 0.5 0.33 0.33
1090 1291 0493 1.0
0193 0195 0204
FCS
750 20 550 25 2
1 0 .3 1.8 0785
550 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
```

Advanced Technology Permiable Membrane Stored Gas Subsystem RCA Price Model H Inputs

```
SOLENOID VALVE
750 20 2 .0017 2
1 0 .3 1.8 0785
2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CREW SERV SEC
750 20 5.5 .1447 2
1 0 .3 1.8 0785
5.5 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
WATER EXTRACTOR
750 20 .2 .0017 2
1 0 .3 1.8 0785
.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PMIGG UNITS
750 20 9.6 .2025 2
1 0 .3 1.8 0785
9.6 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
DUCTING FITTING
750 20 2.3 .0075 2
1 0 .3 1.8 0785
2.3 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
FLOW CONTROL VALVE
750 20 4 .0116 2
1 0 .3 1.8 0785
4 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
COMPRESSOR & MOTOR & INTERCOOLERS
750 20 74 2.2569 2
1 0 .3 1.8 0785
74 6.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
HIGH PRESSURE BOTTLE & FITTING
1500 20 39 1.840 2
2 0 .3 1.8 0785
39 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
```

Advanced Technology Permiable Membrane Stored Gas Subsystem RCA Price Model H Inputs (Continued)

```
HIGH PRESS, GROUND SERVICE CONNECT
750 20 2 .0028 2
1 0 .3 1.8 0785
2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
ORFICE / FITTING
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
HIGH PRESSURE REGULATOR
750 20 3 .0058 2
1 0 .3 1.8 0785
3 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
SOLENOID SHUTOFF VALVE
1500 40 1.5 .0017 2
2 0 .3 1.8 0785
1.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
MANUAL SHUTOFF VALVE
750 20 1 .0035 2
1 0 .3 1.8 0785
1 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CONDENSATE DRAIN / VALVING
750 20 1 .0023 2
1 0 .3 1.8 0785
1 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CHECK VALVE
750 20 .3 .0006 2
1 0 .3 1.8 0785
.3 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PRESSURE SENSOR
2250 60 .2 .0006 2
3 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
```

Advanced Technology Permiable Membrane Stored Gas Subsystem RCA Price Model H Inputs (Continued)

```
TEMP SENSOR
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
O/2 SENSOR
750 20 .2 .0006 2.0
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
FLOW SENSOR
750 20 .3 .0006 2
1 0 .3 1.8 0785
.3 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CONTROLLER / BIT
750 20 8 0.1157 1
1 0.5 .3 1.8 0785
2 6.6 .3 .33 .33
40 8.0 .3 .33 1.0
1090 1291 0493 1.0
0193 0195 0204
DUCTING
750 20 1.2 .0150 2
1 0 .3 1.8 0785
1.2 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
HP RELIEF VALVE
750 20 .3 .0012 2
1 0 .3 1.8 0785
.3 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
SOLENOID VALVE
750 20 .4 .0035 2
1 0 .3 1.8 0785
.4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
```

Advanced Technology Permiable Membrane Stored Gas Subsystem RCA Price Model H Inputs (Continued)

```
ORFICE / FITTING
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
DEMAND REGULATOR
750 20 2.5 .0069 2
1 0 .3 1.8 0785
2.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CLIMB / DIVE VALVE
750 20 2.5 .0069 2
2.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
SCRUB NOZZLES
4500 120 1.5 .0010 2
6 0 .3 1.8 0785
1.5 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CHECK VALVES
1500 120 .3 .0006 2
2 0 .3 1.8 0785
.3 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
BOOST COMPRESSOR. ELECT MOTOR
750 20 11 .1100 2
1 0 .3 1.8 0785
11 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
BOOST COMPRESSOR AFTER COOLER
750 20 3.6 .1360 2
1 0 .3 1.8 0785
3.6 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
INTEGRATION
750 20 .5 .5 5
0 0 0 1.8 0785
1090 1291 0493 0193 0204
```

Advanced Technology Permiable Membrane Stored Gas Subsystem RCA Price Model H Inputs (Continued)

```
PRE COOLER
750 20 36 .7755 2
1 0 .3 1.8 0785
36 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PRESSURE REGULATOR & SHUTOFF
750 20 4.5 .0231 2
1 0 .3 1.8 0785
4.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CREW SERVO PRIMARY HEAT EXCHANGER
750 20 27 .8970 2
1 0 .3 1.8 0785
27 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PRE COOLER TEMP CONTROL VALVE
750 20 4 .0231 2
1 0 .3 1.8 0785
4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
TEMP SENSOR
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
DUCTING / FITTING
750 20 72 1.3426 2
1 0 .3 1.8 0785
72 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
WIRING & MSL
750 20 7.0 .105 2
1 0 0.3 1.8 0785
7.0 5.2 0.5 0.33 0.33
1090 1291 0493 1.0
0193 0195 0204
ECS / IGG
750 20 598 1.3657 2
1 0 .3 1.8 0785
598 6.6 .5 .5 .33
1090 1291 0493 1.0
0193 0195 0204
```

Advanced Technology Permiable Membrane On-Demand Subsystem RCA Price Model H Inputs

```
SOLENOID VALVE IGG
750 20 2.3 .0087 2
1 0 .3 1.8 0785
2.3 6.6 .5 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CREW SERVICES SECONDARY HEAT EXCHANGER IGG
750 20 30 .8160 2
1 0 .3 1.8 0785
30 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
WATER EXTRACTOR IGG
750 20 .4 .0035 2
1 0 .33 1.8 0785
.4 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PMIGG IGG
3750 100 15.6 .2581 2
5 0 .3 1.8 0785
15.6 6.6 .5 .5 .33
1090 1291 0493 1.0
0193 0195 0204
DUCTING & FITTING IGG
750 20 5.9 .0150 2
1 0 .3 1.8 0785
5.9 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
SOLENOID VALVE / ORFICES HPD
3000 80 2 .0022 2
4 0 .3 1.8 0785
2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
ORFICE /FITTING HPD
750 20 0.2 .0006 2
1 0 .3 1.8 0785
0.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
PRESSURE SENSOR HPD
1500 40 .2 .0006 2
2 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
```

Advanced Technology Permiable Membrane On-Demand Subsystem
RCA Price Model H Inputs (Continued)

```
FLOW SENSOR
3750 100 .3 .0005 2
5 0 .3 1.8 0785
.3 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
O/2 SENSOR
3750 100 .2 .0006 2
5 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
TEMP SENSOR HDP
1500 40 0.2 .0006 2
2 0 .3 1.8 0785
0.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CONTROLLER / BIT
750 20 8 0.1157 1
1 .5 .3 1.8 0785
2 6.6 .3 .33 .33
40 8.0 .3 .33 1
1090 1291 0493 1.0
0193 0195 0204
DUCTING HPD
750 20 8.9 .1476 2
1 0 .3 1.8 0785
8.9 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
SOLENOID VALVE LPD
750 20 .4 .0035 2
1 0 .3 1.8 0785
.4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
ORFICE LPD
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
```

Advanced Technology Permiable Membrane On-Demand Subsystem RCA Price Model H Inputs (Continued)

```
DEMAND REGULATOR LPD
750 20 2.5 .0069 2
1 0 .1 1.8 0785
2.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CLIMB / DIVE VALVE LPD
750 20 2.5 .0069 2
1 0 .3 1.8 0785
2.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
SCRUB NOZZLE LPD
750 20 1.5 .0010 2
1 0 .3 1.8 0785
1.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
CHECK VALVE LPD
1500 40 .3 .0006 2
2 0 .3 1.8 0785
.3 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204
INTEGRATION
750 20 .5 .5 5
0 0 0 1.8 0785
1090 1291 0493 0193 0204
```

Advanced Technology Permiable Membrane On-Demand Subsystem
RCA Price Model H Inputs (Continued)

```
PRE COOLER BAS
750 20 13 .3183 2
1 0 .3 1.8 0785
13 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
PRESSURE REGULATOR / S/O BAS
750 20 4 .0174 2
1 0 .3 1.8 0785
4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CREW SERVICES PRIMARY HEAT EXCHANGER BAS
750 20 5.5 .3183 2
1 0 .3 1.8 0785
5.5 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
PRE COOLER TEMP CONTROL VALVE BAS
750 20 3.5 .0174 2
1 0 .3 1.8 0785
3.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
TEMP SENSOR BAS
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
DUCTING / MSC BAS
750 20 24 .3299 2
1 0 .3 1.8 0785
24 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
WIRING & MISC BAS
750 20 5.0 .075 2
1 0 0.3 1 8
5.0 5.2 0.5 0.33 0.33
1090 1291 0493 1.0
0193 0195 0204 C
ECS
750 20 542 24.77 2
1 0 .3 1.8 0785
542 6.6 .5 .5 .33
1090 1291 0493 1.0
0193 0195 0204 C
```

Advanced Technology LN_2 Subsystem RCA Price Model H Inputs

```
DEWARS / FITTING
1500 40 19.3 .8090 2
2 0 .3 1.8 0785
19.3 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
MANIFOLD
750 20 .2 .0012 2
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
RELIEF VENT VALVE
750 20 .8 .0058 2
1 0 .3 1.8 0785
.8 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
FILL VALVE MAN
750 20 1 .0035 2
1 0 .3 1.8 0785
1 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
SOLENOID S/O VALVE
750 20 1.5 .0017 2
1 0 .3 1.8 0785
1.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
GROUND SERVICE LN2
750 1 2 .0029 2
1 0 .3 1.8 0785
2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
FILL LINE
750 20 .1 .0017 2
1 0 .3 1.8 0785
.1 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
QUANTITY SENSOR
1500 40 .2 .0009 2
2 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
```

Advanced Technology LN_2 Subsystem RCA Price Model H Inputs (Continued)

```
PRESSURE SENSOR
750 20 .1 .0006 2
1 0 .3 1.8 0785
.1 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
MAIN DISTRIBUTION LINE HPD
750 20 .6 .0081 2
1 0 .3 1.8 0785
.6 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
ONE STAGE DEMAND REG LPD
750 120 2.1 .0069 2
1 0 .3 1.8 0785
2.1 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
SCRUB HX
750 20 2.5 .0984 2
1 0 .3 1.8 0785
2.5 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
SOLENOID VALVE LPD
750 20 .4 .0035 2
1 0 .3 1.8 0785
.4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
ORFICE / FITTING LPD
750 20 .2 .0035 2
1 0 .3 1.8 0785
.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CLIMB / DIVE VALVE
750 20 2.5 .0069 2
1 0 .3 1.8 0785
2.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
SCRUB NOZZLES LPD
4500 240 1.5 .0010 2
6 0 .3 1.8 0785
1.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
```

Advanced Technology LN_2 Subsystem RCA Price Model H Inputs (Continued)

```
CHECK VALVES LPD
1500 120 0.3 .0006 2
2 0 .3 1.8 0785
.3 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CONTROLLER / BIT
750 20 8 0.1157 1
1 0.5 0.3 1.8 0785
2 6.6 0.3 0.33 0.33
40 8.0 .3 .33 1.0
1090 1291 0493 1.0
0193 0195 0204 C
INTEGRATION
750 20 .5 .5 5
0 0 0 1.8 0785
1090 1291 0493 0193 0204
OK. LO
PTS510 (68) LOGGED OUT AT  15:45 100386
TIME USED=  0:05    0:06    0:02

WAIT...

        USAGE STATISTICS
        ----------------

      Path                           PRU's used

      SBMAC2                          -     108

      Total PRU's used by JLS         :     108
```

Advanced Technology LN_2 Subsystem RCA Price Model H Inputs (Continued)

```
PRE COOLER BAS
750 20 13 .318 2
1 0 .3 1.8 0785
13 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
PRESSURE REGULATOR /  S/O BAS
750 20 4 .0174 2
1 0 .3 1.8 0785
4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CREW SERVICES PRIMARY HEAT EXCHANGER BAS
750 20 9.5 .3183 2
1 0 .3 1.8 0785
9.5 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
PRE COOLER TEMP CONTROL VALVE
750 20 3.5 .0174 2
1.0 0 3 1.8 0785
3.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
TEMP SENSOR BAS
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
DUCTING BAS
750 20 24 .3299 2
1 0 .3 1.8 0785
24 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
WIRING & MISL BAS
750 20 5.0 .075 2
1 0 0.3 1.8 0785
5.0 5.2 0.5 0.33 0.33
1090 1291 0493 1.0
0193 0195 0204 C
ECS
750 20 542 24.77 2
1 0 .3 1.8 0785
542 6.6 .5 .5 .33
1090 1291 0493 1.0
0193 0195 0204 C
```

Advanced Technology Halon Subsystem RCA Price Model H Inputs

```
STORAGE BOTTLES
1500 40 14.5 .6047 2
2 0 .3 1.8 0785
14.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
FILLER VALVE - RES
750 20 1 .0035 2
1 0 .3 1.8 0785
1 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
GROUND SERVICE CONNECTION
750 20 2 .0029 2
1 0 .3 1.8 0785
2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
SOLENOID VALVE S/O VALVE
750 20 1.5 .0017 2
1 0 .3 1.8 0785
1.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
FILL LINE
750 20 .1 .0017 2
1 0 .3 1.8 0785
.1 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
PRESSURE SENSOR
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
QUANTITY SENSOR
1500 40 .2 .0009 2
2 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
RELIEF VALVE
750 20 .3 .0012 2
1 0 .3 1.8 0785
.3 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
```

Advanced Technology Halon Subsystem RCA Price Model H Inputs (Continued)

```
CONTROLLER BIT
750 20 8 0.1157 1
1 0.5 .3 1.8 0785
2 6.6 .3 .33 .33
40 8.0 .3 .33 1.0
1090 1291 0493 1.0
0193 0195 0204 C
HIGH PRESSURE REGULATOR HPD
750 20 3 .0058 2
1 0 .3 1.8 0785
3 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
FLOW CONTROL HPD
750 20 2 .0145 2
1 0 .3 1.8 0785
2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
BLEED AIR SUPPLY DUCTING HPD
750 20 2.1 .0300 2
1 0 .3 1.8 0785
2.1 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
ORFICE / FITTING
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
DUCTING / FITTING HPD
750 20 8.2 .1215 2
1 0 .3 1.8 0785
8.2 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
DEMAND REGULATOR LPD
750 20 2.5 .0069 2
1 0 .3 1.8 0785
2.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
```

Advanced Technology Halon Subsystem RCA Price Model H Inputs (Continued)

```
CLIMB / DIVE VALVE LPD
750 20 2.5 .0069 2
1 0 .3 1.8 0785
2.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CHECK VALVE LPD
750 20 .3 .0006 2
1 0 .3 1.8 0785
.3 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
INTEGRATION
750 20 .5 .5 5
0 0 0 1.8 0785
1090 1291 0493 0193 0204
```

Advanced Technology Halon Subsystem RCA Price Model H Inputs (Continued)

```
PRE COOLER BAS
750 20 13 .0318 2
1 0 .3 1.8 0785
13 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
PRESSURE REGULATOR / S/O BAS
750 20 4 .0017 2
1 0 .3 1.8 0785
4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CREW SERVICES PRIMARY HEAT EXCHANGER BAS
750 20 9.5 .0017 2
1 0 .3 1.8 0785
9.5 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
PRE COOLER TEMP CONTROL VALVE BAS
750 20 3.5 .0017 2
1 0 .3 1.8 0785
3.5 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
TEMP SENSOR BAS
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
DUCTING /FITTING BAS
750 20 24 .330 2
1 0 .3 1.8 0785
24 5.7 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
WIRING & MISL
750 20 5.0 .075 2
1 0 0.3 1.8 0785
5.0 5.2 0.5 0.33 0.33
1090 1291 0493 1.0
0193 0195 0204 C
ECS
750 20 543.4 24.81 2
1 0 .3 1.8 0785
543.4 6.6 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
```

Advanced Technology Foam Subsystem RCA Price Model H Inputs

```
DUCTING HPD
750 20 2.8 .0017 2
1 0 .3 1.8 0785
2.8 5.7 .3 .33 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
ORFICE / FITTING HPD
750 20 .2 .0006 2
1 0 .3 1.8 0785
.2 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
DEMAND REGULATOR LPD
750 20 2.5 .0069 2
1 0 .3 1.8 0785
2.5 6.6 0 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CLIMB / DIVE VALVE LPD
750 20 2.5 .0069 2
1 0 .3 1.8 0785
2.5 6.6 0 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
CHECK VALVE LPD
750 20 .3 .0006 2
1 0 .3 1.8 0785
.3 5.8 .3 .33 .33
1090 1291 0493 1.0
0193 0195 0204 C
INTEGRATION
750 20 .5 .5 5
0 0 0 1.8 0785
1090 1291 0493 0193 0204
```

Advanced Technology Foam Subsystem RCA Price Model H Inputs (Continued)

APPENDIX B.

OBIGGS LCC MODEL INPUTS

The data in this Appendix is the product of the READ program. these examples are for production of 750 shipsets. Data for 1500 shipsets was generated by multiplying TFFH, PFFH, M and SHIPS by a factor of 2. Unit Cost (UC) was multiplied by a factor of .92 to account for the learning curve resulting from doubling the production quantity.

LOGISTICS SUPPORT COST MODEL
INPUT VARIABLES

1. ARBUT -PS- Engine automatic resupply and buildup time in months. (P)

2. BAA -Sy- Available work time per SE in the base shop in labor hours per month.
S = 168 hr/shift * 2 shifts/da=336 hr/person-mo.

3. BBCMH -FL- Average manhours to perform a shop bench check, screening, and fault verification on a removed LRU prior to initiating repair action or condemning the item. (C)

4. BCA -Sy- Total cost of additional items of common base shop support equipment per base required for the system. (C)

5. BCOND -FL- Fraction of removed LRUs expected to result in condemnation at base level. (C)

6. BLR -Sy- Base labor rate, including indirect labor, indirect material and overhead.
S = $21.980/hour (was $19.76/hr)

7. BMC -FL- Base material cost expressed as a fraction of LRU acquisition cost: Average, per-failure cost of labor and materials for stockage, repair, replacement of shop replaceable units (SRU's) or subassemblies required to repair a LRU at an operating base. (C)

8. BMH -FL- Average manhours to perform intermediate-level (base shop) maintenance on a removed LRU including fault isolation, repair, and verification. (C)

9. BMR -Sy- Base consumable material consumption rate. Includes minor items of supply (nuts, washers, rags, cleaning fluid, etc.) which are consumed during repair of items. S = $4.43/hour (was $9.231/hr)

10. BP -PS- Base engine repair cycle time in months. P = 15 to 18 day, average.

11. BPA -Sy- Total cost of special base-shop support equipment, such as overhead cranes and shop fixtures, per base. This category of equipment is largely independent of workload and is not related to repair of specific LRU's. (C)

12. BRCT -Sy- Average base repair cycle time in months. The elapsed time for a RTS item from removal of the failed item until it is returned to base serviceable stock (less time awaiting parts). For modular units like avionic LRU's, the repair of which normally consists of replacing of "plug-in" SRU's: S = 0.164 months or 5 days. For non-modular LRU's: S = 0.20 months or 6 days.

13. BUR -SE- Combined utilization rate for all like items of support equipment at the base level. (C)

14. CAB -SE- Cost per unit of peculiar support equipment for the base shop. (C)

15. CAD -SE- Same as CAB except refers to depot support equipment. (C)

16. CMRI -PS- Combined maintenance removal interval. Average engine operating hours between removals of the whole engine.

17. COB -SE- Annual cost to operate and maintain a unit of support equipment at base level expressed as a fraction of the unit cost (CAB). (C)

18. COD -SE- Same as COB except refers to depot support equipment. (C)

19. CONF -PS- Confidence factor reflecting the probability of satisfying a random demand for a whole engine from serviceable stock to replace a removed engine. S = 0.90

20. CR -Sw- Fraction of software which changes each month. (C)

21. CS -Sy- Cost of software to utilize existing automatic test equipment (ATE) for the system. (C)

22. DAA -Sy- Available work time per item of support equipment (SE) at the depot in labor hours per month. S = 168 hours/shift * 2 shifts/da=336 hr/person-mo.

23. DBCMH -FL- Same as BBCMH except refers to depot-level maintenance. (C)

24. DCA -Sy- Total cost of <u>additional</u> items of common depot support equipment (CSE) required for the system. (C)

25. DCOND -FL- Fractions of FLUs returned to the depot for repair (NRTS) expected to result in condemnation at depot level. (C)

26. DLR -Sy- Depot labor rate, including other direct costs, overhead and G&A.
S = $32.02/hour (was $31.26/hr)

27. DMR -Sy- Same as BMR except refers to depot level maintenance.
S = $13.46/hour (was $10.287/hr)

28. DMC -FL- Same as BMC except refers to depot repair actions. (C)

29. DMH -FL- Same as BMH except refers to depot-level maintenance. (C)

30. DOWN -SE- Fraction of downtime for a unit of support equipment for maintenance and calibration requirements. (C)

31. DP -PS- Depot engine repair cycle time in months. (P)

32. DPA -Sy- Same as BPA except relates to depot support equipment. (C)

33. DRCT -Sy- Weighted average depot repair cycle time in months. The elapsed time for a NRTS item from removal of the failed item until it is returned to depot serviceable stock. This includes the time required for base-to-depot transportation and handling and the shop flow time within the specialized repair activity required to repair the item.

33.1 DRCTC -Sy- For CONUS locations, S = 1.377 months or 42 days (was 50 days) for government-depot repair. S = 1.40 months or 42 days (was 62 days) for contractor repair, input as DRCTC.

33.2 DRCTO -Sy- For overseas locations, S = 1.90 months or 57 days for government-depot repair, S = 2.20 months or 66 days for contractor repair, input as DRCTO.

34. DUR -SE- Same as BUR except refers to depot support equipment. (C)

35. EOH -PS- Average cost per overhaul of the complete engine at the depot expressed as a fraction of the engine unit cost (EUD) including labor and material consumption. Stockage and repair of reparable engine components (LRU's), considered elsewhere, is not included.

36. EPA -PS- Number of engines per aircraft.

37. ERMH -PS- Average labor hours to remove and replace a whole engine including engine trim and runup time.

38. ERTS -PS- Return rate for engines. Fraction of removed whole engines which are returned to service by base maintenance. (The complement, (1-ERTS), is the fraction which must be sent to depot for repair or overhaul).

39. EUC -PS- Expected until cost of a whole engine.

40. FB -Sy- Total cost of new base facilities (including utilities) to be constructed for operation and maintenance of the system, in dollars per base. (C)

41. FC -PS- Fuel cost per unit S = \$0.437/gallon for JP4; \$0.590/gallon for aviation gasoline.

42. FD -Sy- Total cost of new depot facilities (including utilities) to be constructed for maintenance of the system. (C)

43. FLA -Sy- Total cost of peculiar flight-line support equipment and additional items of common flight-line support equipment per base required for the system. (C)

44. FLUNOUN -FL- Word description or name of the LRU - up to 60 alphanumeric characters. (C)

45. FR -PS- Fuel consumption of one engine in units per flying hour. (C)

46. H -Sy- Number pages of depot level technical orders and special repair instructions required to maintain the system. (C)

47. IH -Sy- Cost of interconnecting hardware to utilize existing automatic test equipment for the system. (C)

48. IMC -WS- Initial management cost to introduce a new line item of supply (assembly or piece part) into the Air Force inventory.
S = \$1474.00/item (was \$304.89/item)

49. IMH -FL- Average manhours to perform corrective maintenance of the FLU in place or on line without removal including fault isolation, repair, and verification. (C)

50. INST -Sw- The number of lines of software a programmer can produce in a month. (C)

51. JJ -Sy- Number of pages of organizational and intermediate level technical orders required to maintain the system. (C)

52. K -FL- Number of line items (software or support equipment are examples) used in repair of the LRU. (C)

53.	LS	-PS-	Number of stockage locations for spare engines. (P)
54.	M	-WS-	Number of intermediate repair locations or operating bases authorized to handle the given weapon system. P = 4
55.	MRF	-WS-	Average, per-failure labor hours to complete off-equipment maintenance records. S = .24 hours
56.	MRO	-WS-	Average, per-failure labor hours to complete on-equipment maintenance records. S = .08 hours
57.	MTBF	-FL-	Mean time between maintenance actions in operating hours of the LRU in the operational environment. (C)
58.	N	-Sy-	Number of different LRU's within the system. (C)
59.	NFLUSW	-WS-	Number of FLU software packages within the weapon system. (C)
60.	NRTS	-FL-	Fraction of removed LRU's expected to be returned to the depot for repair. (C)
61.	NSESW	-WS-	Number of SE software packages within the weapon system. (C)
62.	NSYS	-WS-	Number of systems within the weapon system. (C)
63.	OH	-Sw-	The overhead rate which reflects the cost of supporting the programmer. (C)
64.	OS	-WS-	Fraction of total force deployed to overseas locations. P = 0
65.	OST	-WS-	Weighted average order and shipping time in months. The elapsed time between the initiation of a request for a serviceable item and its receipt by the requesting activity.
65.1	OSTCON	-WS-	For CONUS locations, S = 0.262 months or 8 days (was 10 days) input as OSTCON.
65.2	OSTOS	-WS-	For overseas locations, S = 0.526 months (16 days) input as OSTOS. * OST = (OSTCON)(1-OS) + (OSTOS)(OS)
66.	PA	-FL-	Number of new P-coded reparable assemblies within the LRU. (C)
67.	PAMH	-FL-	Average manhours expended in place on the installed system for LRU preparation and access; examples are jacking, unbuttoning, removal of other units, and hookup of support equipment. (C)

68. PC -Sw- The payroll cost per month for one programmer equivalent. (C)

69. PFFH -WS- Peak force flying hours--expected fleet flying hours for one month during the peak usage period. P = 2625 hours.

70. PIUP -WS- Program inventory usage period, operational service life of the weapon system in years. P = 20 years.

71. PMB -WS- Direct productive labor hours per man-year at base level, including "touch" time, transportation time, and setup time. S = 1742.4 hours/man-year.

72. PMD -WS- Direct productive labor hours per man-year at the depot (including "touch" time, transportation time, and setup time. * S= 1743.6 hours/man-year

73. PP -FL- Number of new P-coded base consumable items within the FLU. (C)

74. PSC -WS- Average packing and shipping cost to CONUS locations. S = $2.870/lb (was $1.0021/lb.)

75. PSI -WS- Fraction of initial hardware acquisition used to compute initial training for Life Cycle Cost.

76. PSO -WS- Average packing and shipping cost to overseas location.* S = $1.49/pound.

77. QPA -FL- Quantity per application -- quantity of like LRU's within the parent system. (C)

78. RDC -FL- Estimated RDT&E cost associated with LRU ($ million).

79. RIP -FL- Fraction of LRU failures which can be repaired in place or on line without removal. (C)

80. RMC -WS- Recurring management cost to maintain a line item of supply (assembly or piece part) in the wholesale inventory system.
S = $185.00/item-year (was $173.64)

81. RMH -FL- Average manhours to fault isolate, remove, and replace the LRU on the installed system and verify restoration of the system to operational status. (C)

82. RTOK -FL- Retest OK at intermediate-shop level.

83. RTS -FL- Fraction of removed LRU's expected to be repaired (not RTOK) at base level. (C)

84. SA -WS- Annual base supply line item inventory management cost. S = 9.98/item (was $8.82/item)

85.	SHIPS	-WS-	Number of shipsets to be acquired (not included among original definitions) P = 100
86.	SIZE	-Sw-	The number of lines of software in a particular application. (C)
87.	SMH	-Sy-	Average manhours to perform a scheduled periodic or phased inspection on the system. (C)
88.	SMI	-Sy-	Flying hour interval between scheduled periodic or phased inspections on the system. (C)
89.	SP	-FL-	Number of standard (already stock-numbered) parts within the FLU which will be managed for the first time at bases where this system is deployed. (C)
90.	SR	-WS-	Average per-failure manhours to complete supply transaction records. S = .25 hours
91.	SYSNOUN	-Sy-	Name of the system--up to 60 alphanumeric characters. (C)
92.	TARGAVAL	-WS-	Base-level spares availability objective for weapon system. P = 94%
93.	TCB	-Sy-	Cost of peculiar training per person at base level including instruction and training materials. (C)
94.	TCD	-Sy-	Cost of peculiar training per person at the depot including instruction and training materials. (C)
95.	TCS	-Sw-	The cost to train one programmer or equivalent. (C)
96.	TD	-WS-	Average cost per original page of technical documentation. The average acquisition cost of one page of the reproducible source document not including reproduction costs. S = $538.61/page (was $538.51/page)
97.	TE	-Sy-	Cost of peculiar training equipment required for the system. (C)
98.	TFFH	-WS-	Expected total force flying hours over the program in-ventory usage period (PIUP). P = 630000 hours.
99.	TR	-WS-	Average labor hours per-failure to complete transportation transaction forms. S = .16 hours
100.	TRB	-WS-	Annual turnover rate for base personnel. S = 0.244 (was 0.1598)
101.	TRD	-WS-	Annual turnover rate for depot personnel. S = 0.060 (was 0.0965)

102. TRS -Sw- The turnover rate for programmer personnel. S = 0.0600 or once per 16.7 years (was 0.0965).

103. UC -FL- Expected unit cost of the LRU at the time of initial provisioning. (C)

104. UEBASE -WS- The number of unit equivalent weapon systems per operating base. P = 22.5 systems/base

105. UF -FL- Ratio of operating hours to flying hours for the LRU. (use Factor) (C)

106. W. -FL- LRU unit weight in pounds. (C)

107. XFLU -FL- LRU identification. The assigned five-character alphanumeric work unit code of the LRU. (C)

108. XSE -SE- SE identification--up to 20 alphanumeric characters. (C)

109. XSESW -Sw- The SE identification for imbedded software--up to 20 alphanumeric characters. (C)

110. XSFLUSW -Sw- The LRU identification for imbedded software. The assigned five-character alphanumeric work unit code of the LRU. (C)

111. XSYS -Sy- System identification--the assigned five-character alphanumeric work unit code of the system. (C)

NOTES:

1. FL = Line replaceable unit (LRU) category of variables
2. PS = Propulsion-system variables
3. Sw = Software variables
4. SE = Support equipment variables
5. Sy = Military-system variables
6. WS = System variables
7. (C) = Contractor furnished
8. (P) = Government-furnished program-unique value
9. (S) = Government-furnished standard value

INPUT DATA

OBIGSS 1985 - ADVANCED TECHNOLOGY PERMEABLE MEMBRANE IGG
ON DEMAND

WEAPON SYSTEM VARIABLES

TFFH	PFFH	PIUP	M	DS	NSYS	UEBASE	TARGVL	SHIPS	
3600000.	15000.	20.	25.	.000	1	24.0	.94	750.	
DSTCON	CSTOS	IMC	RMC	FSC	PSO	TRB	TRD	FSI	
.262	.526	1655.00	207.00	2.50	4.23	.244	.060	.030	
TD	SA	MRO	MRF	SR	TR	PMB	PMD	NLRUSW	NSESW
664.380	10.620	.080	.240	.250	.160	1742.	1744.	0	0

PROPULSION SYSTEM VARIABLES

EPA	EUC	CMRI	ERTS	ERMH	EOH	FR
.0	.00	.00	.00	.00	.00	.00

CONF	ARBUT	BP	DP	FC	LS
.00	.00	.00	.00	.94	.00

SUBSYSTEM 1 45000 PERMEABLE MEMBRANE IGG

BCA	DCA	BPA	DPA	FLA	CS	IH	N	
0.	0.	0.	0.	0.	0.	0.	27	
FB	FD	H	JJ	SMH	SMI	TCB	TCD	TE
0.	0.	5000.	350.	0.	.1E+24	4200.	4200.	0.
BLR	DLR	BMR	DMR	BAA	DAA	DRCTC	DRCTD	BRCT
27.670	38.710	5.390	16.590	168.	168.	1.41	1.63	.20

LRU 1 45110 PRE COOLER

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	4418.	.461	3500.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.50	7.00	.50	.50	3.00	5.00	36.00	1.0	.0	.0	.0	0

LRU 2 45111 PRESS REG/SHUTOFF VAL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1870.	.178	2000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.00	1.00	1.00	2.50	3.00	4.50	1.0	.0	.0	.0	0

LRU 3 45112 CREW SERVE PRIMARY HX

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	3446.	.366	5000.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.20	6.50	.50	.50	3.00	5.00	27.00	1.0	.0	.0	.0	0

LRU 4 45113 PRE COOLER TEMP CONT VL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1684.	.164	7000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	4.00	1.0	.0	.0	.0	0

LRU 5 45114 TEMP SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	20000.00	1.0000	.6000	.0000	.0000	.4000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	.20	1.0	.0	.0	.0	0

LRU 6 45115 DUCTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	8046.	.802	15000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	72.00	1.0	.0	.0	.0	0

LRU 7 45116 WIRING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	657.	.101	10777.00	1.0000	.9000	.9500	.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.50	2.00	.00	.00	.00	.00	7.00	1.0	.0	.0	.0	0

ADVANCED TECHNOLOGY PERMEABLE MEMBRANE IGS ON DEMAND (Continued)

LRU 8 45117 ECS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	131721.	8.427	1320.00	1.0000	.0100	.9500	.0500	.0000	.0100	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	48.00	1.0	.0	.0	.0	0

LRU 9 45118 SOLENOID VAL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1029.	.119	8000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	2.30	1.0	.0	.0	.0	0

LRU 10 45119 CREW SEP [illegible] HX

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	3774.	.398	10000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.50	7.00	.50	.50	3.00	5.00	30.00	1.0	.0	.0	.0	0

LRU 11 45120 WATER EXTRACTOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	100.	.022	25000.00	1.0000	.2500	.1500	.6000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.50	3.20	.50	.50	1.50	2.00	.40	1.0	.0	.0	.0	0

LRU 12 45121 PMIGS IGG

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	5.	4316.	1.808	7300.00	1.0000	.2000	.5500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	3.00	3.50	.50	.50	1.00	3.00	15.60	1.0	.0	.0	.0	0

LRU 13 45122 DUCTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	925.	.109	7500.00	1.0000	.4000	.0000	.1000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	5.90	1.0	.0	.0	.0	0

LRU 14 45123 SOL VAL ORIFICES

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	4.	704.	.305	8000.00	1.0000	.5000	.1000	.1000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	3.50	1.00	.00	2.50	3.00	2.00	1.0	.0	.0	.0	0

LRU 15 45124 ORIFICE/FITTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.013	100000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

ADVANCED TECHNOLOGY PERMEABLE MEMBRANE IGG ON DEMAND (Continued)

LRU 16 45125 PRESSURE SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	102.	.033	15000.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.50	2.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 17 45126 FLOW SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	5.	121.	.093	6200.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.50	2.10	.00	.00	.00	.00	.30	1.0	.0	.0	.0	0

LRU 18 45127 O2 SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	5.	102.	.069	2000.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.50	2.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 19 45128 TEMP SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	22.	.033	20000.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	1.50	3.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 20 45129 CONTROLLER/BIT

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	10444.	.834	15000.00	1.0000	.1000	.5000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	1.40	3.00	2.00	300.00	5.00	8.00	1.0	.0	.0	.0	0

LRU 21 45130 DUCTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1720.	.151	15000.00	1.0000	.4000	.0000	.6000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	1.50	.00	.00	.00	.00	8.90	1.0	.0	.0	.0	0

LRU 22 45131 SOLENOID VAL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	218.	.034	8000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.00	3.00	.40	1.0	.0	.0	.0	0

LRU 23 45132 ORIFICE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.013	75000.00	1.0000	.1000	.9500	.0000	.0000	.9000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.00	1.00	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

ADVANCED TECHNOLOGY PERMEABLE MEMBRANE IGG ON DEMAND (Continued)

LRU 24 45133 DEMAND REGULATOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1109.	.118	3500.00	1.0000	.1000	.1000	.9000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
1.00	3.00	7.00	1.00	1.00	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 25 45134 CLIMB DIVE/VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1109.	.118	1000.00	1.0000	.1000	.1000	.9000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
4.00	6.00	15.00	1.00	1.00	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 26 45135 SCRUB NOZZLES

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	704.	.082	100000.00	1.0000	.1000	.1000	.9000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
5.00	4.00	5.00	1.00	1.00	2.50	5.00	1.50	1.0	.0	.0	.0	0

LRU 27 45136 CHECK VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	146.	.044	75000.00	1.0000	.1000	.0000	.0000	.9000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
1.00	2.00	1.00	.00	.00	.00	.00	.50	1.0	.0	.0	.0	0

INPUT DATA

OBIGGS STUDY 1985 - STORED GAS

WEAPON SYSTEM VARIABLES

TFFH	PFFH	PIUP	M	OS	NSYS	UEBASE	TARGVL	SHIPS	
3600000.	15000.	20.	25.	.000	1	24.0	.94	750.	
DSTCON	OSTDS	IMC	SMC	PSC	FSD	TRB	TRD	PSI	
.262	.526	1655.00	207.00	2.50	4.23	.244	.060	.030	
TD	SA	MRO	MRF	SR	TR	PMB	PMD	NLRUSH	NSESW
664.380	10.620	.080	.240	.250	.160	1742.	1744.	0	0

PROPULSION SYSTEM VARIABLES

EPA		EUC	CMRI	ERTS	ERMH	EOH	FR
.0		.00	.00	.00	.00	.00	.00
CONF	ARBUT	SP	DP	FC	LS		
.00	.00	.00	.00	.94	.00		

OBIGGS STUDY 1985 - STORED GAS (Continued)

LRU 32 45541 ORIFICE/FITTINGS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.013	75000.00	1.0000	.1000	.0000	.0000	.9000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	FTOL	K
1.00	2.00	1.00	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 33 45542 DEMAND REGULATOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1109.	.118	3500.00	1.0000	.1000	.1000	.8000	.9000	.9000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	FTOL	K
1.00	3.00	7.00	1.00	1.00	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 34 45543 CLIMB DIVE/VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1109.	.118	1000.00	1.0000	.1000	.1000	.8000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	FTOL	K
4.00	6.00	15.00	1.00	1.00	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 35 45544 SCRUB NOZZLES

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	220.	.190	100000.00	1.0000	.1000	.1000	.8000	.9000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	FTOL	K
5.00	4.00	5.00	1.00	1.00	2.50	5.00	1.50	1.0	.0	.0	.0	0

LRU 36 45546 CHECK VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	73.	.062	75000.00	1.0000	.1000	.0000	.0000	.9000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	FTOL	K
1.00	2.00	1.00	.00	.00	.00	.00	.30	1.0	.0	.0	.0	0

LRU 37 45547 BOOST COMPRESSOR, ELECT MOTOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	4141.	.368	4398.00	1.0000	.0100	.9500	.0500	.0000	.0100	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	FTOL	K
.50	1.00	.50	.50	.50	50.00	5.00	11.00	1.0	.0	.0	.0	0

LRU 38 45548 BOOST COMPRESSOR AFTER COOLER

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	694.	.077	9807.00	1.0000	.0100	.9500	.0500	.9000	.0100	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	FTOL	K
.5	1.00	.50	.50	.50	50.00	5.00	3.60	1.0	.0	.0	.0	0

SUBSYSTEM 1 45000 PERMEABLE MEMBRANE IGS

BCA	DCA	BPA	DPA	FLA	CS	IH	N	
0.	0.	0.	0.	0.	0.	0.	38	
FB	FD	H	JJ	SMH	SMI	TCB	TCD	TE
0.	0.	5000.	350.	0.	.1E+24	4200.	4200.	0.
BLR	DLR	BMR	DMR	BAA	DAA	DRCTC	DRCTO	BRCT
27.620	38.710	5.390	16.590	168.	168.	1.41	1.68	.20

LRU 1 45510 PRE COOLER

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1953.	.217	7500.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.50	7.00	.50	.50	3.00	5.00	14.00	1.0	.0	.0	.0	0

LRU 2 45511 PRESS REG/SHUTOFF VAL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1684.	.164	2000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.00	1.00	1.00	2.50	3.00	4.00	1.0	.0	.0	.0	0

LRU 3 45512 CREW SERVE PRIMARY HX

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1585.	.179	5000.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.20	6.50	.50	.50	3.00	5.00	11.00	1.0	.0	.0	.0	0

LRU 4 45513 PRE COOLER TEMP CONT VL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1496.	.149	7000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	3.50	1.0	.0	.0	.0	0

LRU 5 45514 TEMP SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	20000.00	1.0000	.6000	.0000	.0000	.4000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	1.50	3.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 6 45515 DUCTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	3380.	.360	15000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	26.40	1.0	.0	.0	.0	0

LRU 7 45516 WIRING & MISL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	617.	.096	11019.00	1.0000	.9000	.0000	.0000	.1000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.50	2.00	.00	.00	.00	.00	6.50	1.0	.0	.0	.0	0

LRU 8 45517 ECS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	122684.	7.719	1357.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	.00	1.0	.0	.0	.0	0

LRU 9 45518 SOLENOID VAL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	401.	.055	8600.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	2.00	1.0	.0	.0	.0	0

LRU 10 45519 CREW SER SEC HX

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	870.	.103	10000.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.50	7.00	.50	.50	3.00	5.00	5.50	1.0	.0	.0	.0	0

LRU 11 45520 WATER EXTRACTOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.015	25000.00	1.0000	.2500	.1500	.6000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.50	3.20	.50	.50	1.50	2.00	.20	1.0	.0	.0	.0	0

LRU 12 45521 FRIGG UNITS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	3669.	.329	7300.00	1.0000	.0100	.2000	.5500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	3.00	3.50	.50	.50	1.00	3.00	9.60	1.0	.0	.0	.0	0

LRU 13 45522 DUCTING FITTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	409.	.057	75000.00	1.0000	.4000	.0000	.1000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	2.30	1.0	.0	.0	.0	0

LRU 14 45523 FLOW CONTROL VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	651.	.093	9502.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	4.00	1.0	.0	.0	.0	0

LRU 15 45524 COMPRESSOR & MOTOR & INTERCOOLERS

	1.	27432.	2.045	2251.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	.50	.50	.50	50.00	5.00	74.00	1.0	.0	.0	.0	0

OBIGGS STUDY 1985 - STORED GAS (Continued)

LRU 16 45525 HIGH PRESSURE BOTTLE & FITTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	11355.	1.042	3001.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	39.00	1.0	.0	.0	.0	0

LRU 17 45526 HIGH PRESS. GROUND SERVICE CONNECT

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	401.	.055	11065.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
.50	1.00	.50	.50	.50	50.00	5.00	2.00	1.0	.0	.0	.0	0

LRU 18 45527 ORIFICE/FITTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.013	100000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 19 45528 HIGH PRESSURE REGULATOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1304.	.134	6480.00	1.0000	.0100	.9500	.0500	.0000	.0100	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
.50	1.00	.50	.50	.50	50.00	5.00	3.00	1.0	.0	.0	.0	0

LRU 20 45529 SOLENOID SHUTOFF VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	618.	.139	8000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	1.50	1.0	.0	.0	.0	0

LRU 21 45530 MANUAL SHUTOFF VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	220.	.035	13623.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
.50	1.00	.50	.50	.50	50.00	5.00	1.00	1.0	.0	.0	.0	0

LRU 22 45531 CONDENSATION DRAIN/VALVING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	220.	.035	13623.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	1.00	1.0	.0	.0	.0	0

LRU 23 45532 CHECK VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	77.	.017	19550.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
.50	1.00	.50	.50	.50	50.00	5.00	.30	1.0	.0	.0	.0	0

OEIGGS STUDY 1985 - STORED GAS (Continued)

LRU 24 45533 PRESSURE SENSOR

PAMH	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	3.	94.	.045	15000.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
1.00	1.50	2.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 25 45534 TEMP SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	20000.00	1.0000	.6000	.0000	.0000	.4000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
1.50	1.50	3.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 26 45535 O2 SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	20000.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
1.00	1.50	2.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 27 45536 FLOW SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	168.	.026	6200.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
1.00	1.50	2.10	.00	.00	.00	.00	.30	1.0	.0	.0	.0	0

LRU 28 45537 CONTROLLER/BIT

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	10444.	.834	18000.00	1.0000	.0100	.5000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
.50	1.00	1.40	3.00	2.00	3.00	5.00	6.00	1.0	.0	.0	.0	0

LRU 29 45539 DUCTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	233.	.040	15000.00	1.0000	.4000	.0000	.6000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
1.50	3.00	1.50	.00	.00	.00	.00	1.20	1.0	.0	.0	.0	0

LRU 30 45539 HF RELIEF VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	77.	.017	19550.00	1.0000	.0100	.9500	.0500	.0000	.0100	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
.50	1.00	.50	.50	.50	50.00	5.00	.30	1.0	.0	.0	.0	0

LRU 31 45540 SOLENOID VAL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	218.	.034	8000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SF	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	.40	1.0	.0	.0	.0	0

INPUT DATA

OBIGGS STUDY 1985 - HALON

WEAPON SYSTEM VARIABLES

TFFH	PFFH	PIUP	M	OS	NSYS	UEBASE	TARGVL	SHIPS
3500000.	15000.	20.	25.	.000	2	24.0	.94	750.

OSTCON	OSTOS	IMC	RMC	PSC	PSO	TRB	TRD	PSI
.262	.526	1655.00	207.00	2.50	4.23	.244	.060	.030

TD	SA	MRO	MRF	SR	TR	PMB	PMD	NURUSW	NSESK
664.380	10.620	.080	.240	.250	.160	1742.	1744.	0	0

PROPULSION SYSTEM VARIABLES

EPA	EUC	CMRI	ERTS	ERMH	EOH	FR
87.0	.00	3.00	.00	.00	.00	.50

CONF	ARBUT	BF	DP	FC	LS
.00	.00	.00	.00	3.03	1.00

SUBSYSTEM 1 23000 HALON CONSUMPTION

BCA	DCA	BPA	DPA	FLA	CS	IH	N	
0.	0.	0.	0.	0.	0.	0.	0	
FB	FD	H	JJ	SMH	SMI	TCB	TCD	TE
0.	0.	0.	0.	0.	.1E+24	0.	0.	0.
BLR	DLR	BMR	DMR	BAA	DAA	DRCTC	DRCTO	BRCT
.000	.000	.000	.000	0.	0.	.00	.00	.00

SUBSYSTEM 2 45000 PERMEABLE MEMBRANE 166

BCA	DCA	BPA	DPA	FLA	CS	IH	N	
0.	0.	0.	0.	41148.	0.	0.	25	
FB	FD	H	JJ	SMH	SMI	TCB	TCD	TE
0.	0.	5000.	350.	1.	.1E+24	4200.	4200.	0.
BLR	DLR	BMR	DMR	BAA	DAA	DRCTC	DRCTO	BRCT
27.620	38.710	5.390	16.590	168.	168.	1.41	1.68	.20

LRU 1 45210 PRE COOLER BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1832.	.264	3500.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.50	7.00	.50	.50	3.00	5.00	13.00	1.0	.0	.0	.0	0

LRU 2 45211 PRESS REG/SHUTOFF BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1684.	.164	2000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.00	1.00	1.00	2.50	3.00	4.00	1.0	.0	.0	.0	0

LRU 3 45212 CREW SERVE PRIMARY HX BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1396.	.157	5000.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.20	6.50	.50	.50	3.00	5.00	9.50	1.0	.0	.0	.0	0

LRU 4 45213 PRE COOLER TEMP CONT VL

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1496.	.149	7000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	3.50	1.0	.0	.0	.0	0

LRU 5 45214 TEMP SENSOR BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	20000.00	1.0000	.6000	.0000	.0000	.4000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	1.50	3.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 6 45215 DUCTING BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	3112.	.334	15000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	24.00	1.0	.0	.0	.0	0

LRU 7 45216 WIRING & MISL RAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	9.	48.	.090	10000.00	1.0000	.9000	.0000	.0000	.1000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	2.50	2.00	.00	.00	50.00	5.00	.55	1.0	.0	.0	.0	0

LRU 8 45217 ECS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	121072.	7.842	1363.00	1.0000	.0100	.5500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	8.00	1.0	.0	.0	.0	0

LRU 9 45218 STORAGE BOTTLES

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	4710.	.801	8000.00	1.0000	.5100	.0500	.4500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	8.00	.00	1.00	2.00	3.00	14.50	1.0	.0	.0	.0	0

LRU 10 45219 FILLER VALVE-RES

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	220.	.035	100000.00	1.0000	.5000	.1500	.3500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.80	7.00	.50	.50	2.50	2.50	30.00	1.0	.0	.0	.0	0

LRU 11 45220 GROUND SERVICE CONNECTION

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	401.	.055	3000.00	1.0000	.5000	.1500	.3500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	4.50	5.00	.50	.50	2.50	2.50	2.00	1.0	.0	.0	.0	0

LRU 12 45221 SOLENOID VALVE S/O VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	704.	.062	5500.00	1.0000	.5000	.1500	.3500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	4.00	4.20	1.00	1.00	2.50	3.00	1.50	1.0	.0	.0	.0	0

LRU 13 45222 FILL LINE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	28.	.009	100000.00	1.0000	.5100	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.80	3.00	.00	.00	.00	.00	.10	1.0	.0	.0	.0	0

LRU 14 45223 PRESSURE SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	15000.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.50	2.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 15 45224 QUANTITY SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	102.	.033	6500.00	1.0000	.5000	.0000	.0000	.5000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.50	5.00	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 16 45225 RELIEF VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	77.	.017	7000.00	1.0000	.5000	.1500	.3500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	4.00	4.00	1.00	.50	2.50	2.50	.30	1.0	.0	.0	.0	0

LRU 17 45226 CONTROLLER BIT

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	10444.	.834	18000.00	1.0000	.0100	.5000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	1.40	3.00	2.00	5.00	5.00	6.00	1.0	.0	.0	.0	0

LRU 18 45227 HIGH PRESSURE REGULATOR HPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1304.	.134	5500.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	2.00	3.00	1.00	1.00	2.50	3.00	3.00	1.0	.0	.0	.0	0

LRU 19 45228 FLOW CONTROL HPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	908.	.101	7000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	4.00	2.00	1.0	.0	.0	.0	0

LRU 20 45229 BLEED AIR SUPPLY DUCTING HPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	379.	.056	8000.00	1.0000	.0500	.0000	.0000	.9500	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	3.00	7.00	.00	.00	.00	.00	2.10	1.0	.0	.0	.0	0

LRU 21 45230 ORFICE/FITTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.013	10000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 22 45231 DUCTING/FITTING HPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1229.	.142	7500.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	9.20	1.0	.0	.0	.0	0

LRU 23 45232 DEMAND REGULATOR LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1109.	.118	3500.00	1.0000	.1000	.1000	.8000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
1.00	3.00	7.00	1.00	1.00	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 24 45233 CLIMB/DIVE VALVE LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1109.	.116	1000.00	1.0000	.1000	.1000	.8000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
4.00	6.00	15.00	1.00	1.00	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 25 45234 CHECK VALVE LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	168.	.026	75000.00	1.0000	.1000	.0000	.0000	.9000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
1.00	2.00	5.00	.00	.00	.00	.00	.30	1.0	.0	.0	.0	0

INPUT DATA

OBIGGS STUDY 1985 - LIQUID NITROGEN

WEAPON SYSTEM VARIABLES

TFFH	PFFH	PIUF	M	OS	NSYS	UEBASE	TARGVL	SHIPS	
3600000.	15000.	20.	25.	.000	2	24.0	.94	750.	
OSTCON	OSTOS	IMC	RMC	PSC	PSB	TRB	TRD	PSI	
.262	.526	1655.00	207.00	2.50	4.00	.244	.060	.030	
TD	SA	MRC	MRF	SR	TR	PMB	PMD	NLFUSW	NSEGW
664.380	10.620	.080	.240	.250	.160	1742.	1744.	0	0

PROPULSION SYSTEM VARIABLES

EPA		EUC	CMRI	ERTS	ERMH	ECH	FR
81.0		.00	3.00	.00	.00	.00	.50
CONF	ARBUT	BP	DP	FC	LS		
.00	.00	.00	.00	.34	1.00		

OBIGGS STUDY 1985 - LIQUID NITROGEN (Continued)

SUBSYSTEM 1 23000 LIQUID NITROGEN CONSUMPTION

BCA	DCA	BPA	DPA	FLA	CS	IM	N	
0.	0.	0.	0.	0.	0.	0.	0	
FB	FD	H	JJ	SMH	SMI	TCB	TCD	TE
0.	0.	0.	0.	0.	.1E-24	0.	0.	0.
BLR	DLR	BMR	DMS	BAA	DAA	DRCTC	DRCTD	BRCT
.000	.000	.000	.000	0.	0.	.00	.00	.00

****

SUBSYSTEM 2   45000   PERMEABLE MEMBRANE IGG

BCA	DCA	BPA	DPA	FLA	CS	IH	N	
0.	0.	0.	0.	426512.	0.	0.	26	
FB	FD	H	JJ	SMH	SMI	TCB	TCD	TE
0.	0.	5000.	350.	0.	.1E+24	4200.	4200.	0.
BLR	DLR	BMR	DMR	BAA	DAA	DRCTC	DRCTO	BRCT
27.670	38.710	5.390	16.590	168.	168.	1.41	1.68	.20

LRU 1   45310   PRE COOLER BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1832.	.204	3500.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.50	7.00	.50	.50	3.00	5.00	13.00	1.0	.0	.0	.0	0

LRU 2   45311   PRESS REG/SHUTOFF VAL BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1664.	.164	2000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.00	1.00	1.00	2.50	3.00	4.00	1.0	.0	.0	.0	0

LRU 3   45312   CREW SERVE PRIMARY HX BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	870.	.103	5000.00	1.0000	.3000	.0500	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.20	6.50	.50	.50	3.00	5.00	5.50	1.0	.0	.0	.0	0

LRU 4   45313   PRE COOLER TEMP CONT VL BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1496.	.149	7000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	3.50	1.0	.0	.0	.0	0

LRU 5   45314   TEMP SENSOR BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	25000.00	1.0000	.6000	.0000	.0000	.4000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	1.50	3.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 6   45315   DUCTING +MSC BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	3112.	.334	15000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	24.00	1.0	.0	.0	.0	0

LRU 7 45316 WIRING & MISC BAS

	QPA	UC	RDC	MTBF	UF	RIF	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	637.	.103	11922.00	1.0000	.9000	.0000	.0000	.1000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
1.50	2.50	2.00	.00	.00	.00	.00	7.00	1.0	.0	.0	.0	0

LRU 8 45317 ECS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	121072.	7.842	1363.00	1.0000	.5000	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	8.00	1.0	.0	.0	.0	0

LRU 9 45318 DEWARS/FITTING

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	6084.	1.016	2500.00	1.0000	.5000	.0500	3.0000	.4500	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SP	RTOK	K
1.50	3.00	8.00	.00	.00	2.00	1.00	19.30	1.0	.0	.0	.0	0

LRU 10 45319 MANIFOLD

	CPA	UC	RDC	MTBF	UF	RIF	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	10000.00	1.0000	.5000	.1500	2.5000	.3500	.0000	.0070	.0070
PAMH	IMH	SMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.00	4.00	5.00	.00	2.50	.50	5.00	.20	1.0	.0	.0	.0	0

LRU 11 45320 RELIEF VENT VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	181.	.034	7000.00	1.0000	.5000	.1500	2.5000	.3500	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.00	4.00	4.00	1.00	.00	2.50	.50	.50	1.0	.0	.0	.0	0

LRU 12 45321 FILL VALVE MAN

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	220.	.035	6000.00	1.0000	.5000	.1500	2.5000	.3500	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.00	6.50	1.00	.50	.00	2.50	.50	1.00	1.0	.0	.0	.0	0

LRU 13 45322 SOLENOID S/O VALVE

	QPA	UC	RDC	MTBF	UF	RIF	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	704.	.032	5500.00	1.0000	.5000	.1500	3.0000	.3500	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.00	4.00	4.20	1.00	.00	2.50	1.00	1.50	1.0	.0	.0	.0	0

LRU 14 45323 GROUND SERVICE LN2

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	401.	.017	3000.00	1.0000	.5000	.1500	2.5000	.3500	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.00	4.50	5.00	.50	.00	2.50	5.00	2.00	1.0	.0	.0	.0	0

LRU 15 45324 FILL LINE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	28.	.009	100000.00	1.0000	.5000	.0000	.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.80	3.00	.00	.50	.00	.00	.10	1.0	.0	.0	.0	0

LRU 16 45325 QUANTITY SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	102.	.033	6500.00	1.0000	.5000	.0000	.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.50	5.00	.00	.50	.00	.00	.20	1.0	.0	.0	.0	0

LRU 17 45326 PRESSURE SENSOR

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	64.	.013	15000.00	1.0000	.5000	.0000	.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	1.50	2.10	.00	.50	.00	.00	.10	1.0	.0	.0	.0	0

LRU 18 45327 MAIN DISTRIBUTION LINE HPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	129.	.026	1000.00	1.0000	.0500	.0000	.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	3.00	7.00	.50	.95	.00	.00	.63	1.0	.0	.0	.0	0

LRU 19 45328 ON STAGE DEMAND REG LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	949.	.452	3500.00	1.0000	.1000	.1000	3.0000	.8000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	3.00	7.00	.50	.00	2.50	1.00	2.10	1.0	.0	.0	.0	0

LRU 20 45329 SCRUB HX

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	440.	.061	20000.00	1.0000	.1000	.1000	.5000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W		PP	SP	RTOK	K
15.00	4.00	9.00	.50	.00	2.50	1.00	2.50		.0	.0	.0	0

LRU 21 45330 SOLENOID VALVE LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	218.	.034	8000.00	1.0000	.5000	.1000	3.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.50	2.00	3.50	.50	.40	2.50	1.00	.40	1.0	.0	.0	.0	0

LRU 22 45331 ORFICE FITTING LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.014	75000.00	1.0000	.1000	.0000	.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.00	1.00	.50	.90	.00	.00	.20	1.0	.0	.0	.0	0

LRU 23 45332 CLIMB/DIVE VALVE

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1109.	.118	1000.00	1.0000	.1000	.1000	3.0000	.8000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
4.00	6.00	15.00	.50	.00	2.50	1.00	2.50	1.0	.0	.0	.0	0

LRU 24 45333 SCRUB NOZZLES LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	6.	504.	.663	100000.00	1.0000	.1000	.1000	5.0000	.8000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
15.00	4.00	5.00	.50	.00	2.50	1.00	1.50	1.0	.0	.0	.0	0

LRU 25 45334 CHECK VALVES LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	2.	67.	.062	75000.00	1.0000	.1000	.0000	.0000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.00	1.00	.50	.90	.00	.00	.30	1.0	.0	.0	.0	0

LRU 26 45335 CONTROLLER/BIT

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	10444.	.834	18000.00	1.0000	.1000	.5000	5.0000	.4000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	1.40	3.00	.00	5.00	2.00	6.00	1.0	.0	.0	.0	0

INPUT DATA

OBIGGS STUDY 1985 - FOAM

WEAPON SYSTEM VARIABLES

TFFH	PFFH	PIUP	M	OS	NSYS	UEBASE	TARGVL	SHIPS	
3600000.	15000.	20.	25.	.000	1	24.0	.94	750.	
OSTCON	OSTOS	IMC	RMC	PSC	PSO	TRB	TRD	PSI	
.262	.526	1655.00	207.00	2.50	4.23	.244	.060	.030	
TD	SA	MRD	MRF	SR	TR	PMB	PMD	NLFUSW	NSESW
664.380	10.620	.080	.240	.250	.160	1742.	1744.	0	0

PROPULSION SYSTEM VARIABLES

EPA	EUC	CMPI	ERTS	ERMH	EOH	FR
.0	.00	.00	.00	.00	.00	.00

CONF	ARBUT	BF	DP	FC	LS
.00	.00	.00	.00	.94	.00

SUBSYSTEM 1 45000 PERMEABLE MEMBRANE ISG

BCA	DCA	BPA	DPA	FLA	OS	IH	N	
0.	0.	0.	0.	0.	0.	0.	14	
FB	FD	F	JJ	SMH	SMI	TCB	TCD	TE
0.	0.	5000.	350.	0.	.1E+24	4200.	4200.	0.
BLR	DLR	BMR	DMR	BAA	DAA	BRCTC	DRCTD	BRCT
27.620	38.717	5.390	16.590	168.	168.	1.41	1.68	.20

LRU 1 45410 PRE COOLER BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1832.	.204	3500.00	1.0000	.3000	.5000	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.50	7.00	.50	.50	3.00	5.00	13.00	1.0	.0	.0	.0	0

LRU 2 45411 PRESS REG/SHUTOFF VAL BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1684.	.164	2000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.00	1.00	1.00	2.50	3.00	4.00	1.0	.0	.0	.0	0

LRU 3 45412 CREW SERVE PRIMARY HX BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1397.	.159	5000.00	1.0000	.3000	.5000	.6500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.20	6.50	.50	.50	3.00	5.00	9.50	1.0	.0	.0	.0	0

LRU 4 45413 PRE COOLER TEMP CONT VL BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1495.	.149	7000.00	1.0000	.5000	.1000	.4000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.00	3.50	1.00	1.00	2.50	3.00	3.50	1.0	.0	.0	.0	0

LRU 5 45414 TEMP SENSOR BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	117.	.020	20000.00	1.0000	.6000	.0000	.0000	.4000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	1.50	3.10	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 6 45415 DUCTING/FITTING BAS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	3112.	.034	15000.00	1.0000	.4000	.0000	.0000	.6000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	3.00	5.00	.00	.00	.00	.00	24.00	1.0	.0	.0	.0	0

LRU 7 45416 WIRING & MISC

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	80.	.494	11992.00	1.0000	.9000	.0000	.0000	.1000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PF	SF	RTOK	K
1.50	2.50	2.00	.00	.00	.00	.00	5.00	1.0	.0	.0	.0	0

LRU 8 45417 ECS

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	121422.	7.651	1362.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	.50	.50	.50	500.00	5.00	6.60	1.0	.0	.0	.0	0

LRU 9 45418 DUCTING HPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	485.	.065	10575.00	1.0000	.0100	.9500	.0500	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
.50	1.00	.50	.50	.50	50.00	5.00	2.80	1.0	.0	.0	.0	0

LRU 10 45419 ORFICE/FITTING HPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	54.	.013	75000.00	1.0000	.1000	.0000	.0000	.9000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.00	1.00	.00	.00	.00	.00	.20	1.0	.0	.0	.0	0

LRU 11 45420 DEMAND REGULATOR LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1166.	.140	3500.00	1.0000	.1000	.1000	.8000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	3.00	7.00	1.00	.10	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 12 45421 CLIMB/DIVE VALVE LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	1166.	.140	1000.00	1.0000	.1000	.1000	.8000	.0000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
4.00	6.00	15.00	1.00	.10	2.50	3.00	2.50	1.0	.0	.0	.0	0

LRU 13 45422 CHECK VALVE LPD

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	77.	.017	75000.00	1.0000	.1000	.0000	.0000	.9000	.0000	.0070	.0070
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
1.00	2.00	1.00	.00	.00	.00	.00	15.60	1.0	.0	.0	.0	0

LRU 14 45423 FOAM

	QPA	UC	RDC	MTBF	UF	RIP	RTS	NRTS	BCOND	DCOND	BMC	DMC
	1.	6457.	.000	43800.00	1.0000	1.0000	.0000	.0000	.0000	1.0000	.0000	1.0000
PAMH	IMH	RMH	BBCMH	DBCMH	BMH	DMH	W	PA	PP	SP	RTOK	K
500.00	.00	1000.00	.00	.00	.00	.00	21.00	.0	.0	.0	.0	0

APPENDIX C

LIFE CYCLE COST REPORT SUMMARY

LIFE CYCLE COST REPORT   STORED GAS, 750 UNITS

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					15042000.
HARDWARE ACQUISITION:					174413500.
45000 PERMEABLE MEMBRANE 166				212283.	
45510 PRE COOLER	1	1953.	1953.		
45511 PRESS REG/SHUTOFF VAL	1	1684.	1684.		
45512 CREW SERVE PRIMARY HX	1	1585.	1585.		
45513 PRE COOLER TEMP CONT VL	1	1496.	1496.		
45514 TEMP SENSOR	1	117.	117.		
45515 DUCTING	1	3380.	3380.		
45516 WIRING & MISL	1	617.	617.		
45517 ECS	1	122684.	122684.		
45518 SOLENOID VAL	1	401.	401.		
45519 CREW SER SEC HX	1	870.	870.		
45520 WATER EXTRACTOR	1	54.	54.		
45521 PRIOR UNITS	1	3669.	3669.		
45522 DUCTING FITTING	1	409.	409.		
45523 FLOW CONTROL VALVE	1	651.	651.		
45524 COMPRESSOR & MOTOR & INTERCOOLERS	1	27432.	27432.		
45525 HIGH PRESSURE BOTTLE & FITTING	2	11355.	22710.		
45526 HIGH PRESS. GROUND SERVICE CONNECT	1	401.	401.		
45527 ORFICE/FITTING	1	54.	54.		
45528 HIGH PRESSURE REGULATOR	1	1304.	1304.		
45529 SOLENOID SHUTOFF VALVE	2	618.	1236.		
45530 MANUAL SHUTOFF VALVE	1	220.	220.		
45531 CONDENSATION DRAIN/VALVING	1	220.	220.		
45532 CHECK VALVE	1	77.	77.		
45533 PRESSURE SENSOR	3	94.	282.		
45534 TEMP SENSOR	1	117.	117.		
45535 O2 SENSOR	1	117.	117.		
45536 FLOW SENSOR	1	168.	168.		
45537 CONTROLLER/BIT	1	10444.	10444.		
45538 DUCTING	1	233.	233.		
45539 HP RELIEF VALVE	1	77.	77		
45540 SOLENOID VAL	1	218.	218.		
45541 ORIFICE/FITTING	1	54.	54.		
45542 DEMAND REGULATOR	1	1109.	1109.		
45543 CLIMB DIVE/VALVE	1	1109.	1109.		
45544 SCRUB NOZZLES	1	220.	220.		
45546 CHECK VALVE	2	78.	156.		
45547 BOOST COMPRESSOR, ELECT MOTOR	1	4141.	4141.		
45548 BOOST COMPRESSOR AFTER COOLER	1	694.	694.		
SUBTOTAL				212283.	
WARRANTY(1%)				2123.	
HARDWARE PER SHIP SET				214406.	
TOTAL HARDWARE (750 SHIP SETS)				160804400.	
SUPPORT INVESTMENT				13609130.	
INITIAL SPARES COST			5230565.		
INITIAL SUPPORT EQUIPTMENT			0.		
INITIAL TRAINING (3.0% OF TOTAL ACQUISITION)			4824131.		
TECHNICAL PUBLICATION			3554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					107388000.
CONDEMNATION SPARES			444182.		
ON-EQUIPTMENT MAINTENANCE			3681144.		
OFF-EQUIPTMENT MAINTENANCE			99989750.		
INTERMEDIATE		98167800.			
DEPOT		1569579.			
TRANSPORTATION		252370.			
INVENTORY MANAGEMENT			780260.		
SUPPORT EQUIPTMENT			0.		
PERSONNEL TRAINING			2064600.		
MANAGEMENT & TECHNICAL DATA			428045.		
FUEL CONSUMPTION			0.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					296843500.

LIFE CYCLE COST REPORT ON DEMAND, 750 UNITS

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					14915000.
HARDWARE ACQUISITION:					163366000.
45000 PERMEABLE MEMBRANE 166				198850.	
45110 PRE COOLER	1	4418.	4418.		
45111 PRESS REG/SHUTOFF VAL	1	1870.	1870.		
45112 CREW SERVE PRIMARY HX	1	3446.	3446.		
45113 PRE COOLER TEMP CONT VL	1	1684.	1684.		
45114 TEMP SENSOR	1	117.	117.		
45115 DUCTING	1	8046.	8046.		
45116 WIRING	1	657.	657.		
45117 ECS	1	131721.	131721.		
45118 SOLENOID VAL	1	1029.	1029.		
45119 CREW SER SEC HX	1	3774.	3774.		
45120 WATER EXTRACTOR	1	100.	100.		
45121 PHI98 100	5	4316.	21580.		
45122 DUCTING	1	925.	925.		
45123 SOL VAL ORIFICES	4	704.	2816.		
45124 ORIFICE/FITTING	1	54.	54.		
45125 PRESSURE SENSOR	2	102.	204.		
45126 FLOW SENSOR	5	121.	605.		
45127 O2 SENSOR	5	102.	510.		
45128 TEMP SENSOR	2	22.	44.		
45129 CONTROLLER/BIT	1	10444.	10444.		
45130 DUCTING	1	1320.	1320.		
45131 SOLENOID VAL	1	218.	218.		
45132 ORIFICE	1	54.	54.		
45133 DEMAND REGULATOR	1	1109.	1109.		
45134 CLIMB DIVE/VALVE	1	1109.	1109.		
45135 SCRUB NOZZLES	1	704.	704.		
45136 CHECK VALVE	2	146.	292.		
SUBTOTAL				198850.	
WARRANTY(1%)				1989.	
HARDWARE PER SHIP SET				200839.	
TOTAL HARDWARE (750 SHIP SETS)				150628900.	
SUPPORT INVESTMENT				12737000.	
INITIAL SPARES COST			4663784.		
INITIAL SUPPORT EQUIPTMENT			0.		
INITIAL TRAINING (3.0% OF TOTAL ACQUISITION)			4518867.		
TECHNICAL PUBLICATION			3554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					55820000.
CONDEMNATION SPARES			1470518.		
ON-EQUIPTMENT MAINTENANCE			4644134.		
OFF-EQUIPTMENT MAINTENANCE			47716180.		
INTERMEDIATE		45989230.			
DEPOT		1374506.			
TRANSPORTATION		352441.			
INVENTORY MANAGEMENT			546570.		
SUPPORT EQUIPTMENT			0.		
PERSONNEL TRAINING			1016746.		
MANAGEMENT & TECHNICAL DATA			434735.		
FUEL CONSUMPTION			0.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					234109900.

LIFE CYCLE COST REPORT HALON 750.

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					11556[illegible]0.
HARDWARE ACQUISITION:					13267[illegible]0.
23000 HALON				0.	
SUBTOTAL				0.	
WARRANTY(1%)				0.	
HARDWARE PER SHIP SET				0.	
45000 PERMEABLE MEMBRANE IGG				159015.	
45210 PRE COOLER BAS	1	1922.	19[illegible].		
45211 PRESS REG/SHUTOFF BAS	1	1694.	1694.		
45212 CREW SEAVE PRIMARY HE BAS	1	1376.	1[illegible].		
45213 PRE COOLER TEMP CONT VL	1	1496.	1496.		
45214 TEMP SENSOR BAS	1	112.	112.		
45215 DUCTING BAS	1	2112.	2112.		
45216 WIRING & MISC BAS	9	48.	432.		
45217 ECS	1	121072.	121072.		
45218 STORAGE BOTTLES	2	4710.	9420.		
45219 FILLER VALVE-RES	1	220.	220.		
45220 GROUND SERVICE CONNECTION	1	401.	401.		
45221 SOLENOID VALVE S/O VALVE	1	704.	704.		
45222 FILL LINE	1	28.	28.		
45223 PRESSURE SENSOR	1	112.	112.		
45224 QUANTITY SENSOR	2	192.	2[illegible].		
45225 RELIEF VALVE	1	77.	77.		
45226 CONTROLLER BIT	1	10444.	10444.		
45227 HIGH PRESSURE REGULATOR HPD	1	1304.	1304.		
45228 FLOW CONTROL HPD	1	9[illegible]8.	9[illegible]9.		
45229 BLEED AIR SUPPLY DUCTING HPD	1	378.	376.		
45230 ORIFICE/FITTING	1	54.	54.		
45231 DUCTING-FITTING HPD	1	1229.	1229.		
45232 DEMAND REGULATOR LPD	1	1109.	1109.		
45233 CLIMB-DIVE VALVE LPD	1	1109.	1109.		
45234 CHECK VALVE LPD	1	169.	169.		
SUBTOTAL				159015.	
WARRANTY(1%)				1590.	
HARDWARE PER SHIP SET				16[illegible]05.	
TOTAL HARDWARE (750 SHIP SETS)				12[illegible]453900.	
SUPPORT INVESTMENT				12225309.	
INITIAL SPARES COST			4026551.		
INITIAL SUPPORT EQUIPMENT			10[illegible].		
INITIAL TRAINING ([illegible]% OF TOTAL ACQUISITION)			[illegible]		
TECHNICAL PUBLICATION			1554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					52619[illegible]0.
CONDEMNATION SPARES			664964.		
ON EQUIPMENT MAINTENANCE			4176670.		
OFF EQUIPMENT MAINTENANCE			45[illegible]9770.		
INTERMEDIATE		4346792[illegible].			
DEPOT		1411[illegible].			
TRANSPORTATION		184662.			
INVENTORY MANAGEMENT			[illegible]		
SUPPORT EQUIPMENT			[illegible]		
PERSONNEL TRAINING			[illegible]		
MODIFICATION & TECHNICAL DATA			[illegible]		
FUEL CONSUMPTION			47[illegible].		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					67[illegible].

LIFE CYCLE COST REPORT LIQUID NITROGEN 750

	QTY	UNIT COST	TOTAL COST	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					12442000.
HARDWARE ACQUISITION:					144416000.
45000 PERMEABLE MEMBRANE 166				0.	
SUBTOTAL				0.	
WARRANTY(1%)				0.	
HARDWARE PER SHIP SET				0.	
23000 LIQUID NITROGEN CONSUMPTION				161408.	
45310 PRE COOLER HAS	1	1832.	1832.		
45311 PRESS REG/SHUTOFF VAL BAS	1	1684.	1684.		
45312 CREW SERVE PRIMARY HX BAS	1	870.	870.		
45313 PRE COOLER TEMP CONT VL BAS	1	1496.	1496.		
45314 TEMP SENSOR BAS	1	117.	117.		
45315 DUCTING /MSC BAS	1	3112.	3112.		
45316 WIRING & MISC BAS	1	637.	637.		
45317 ECS	1	121072.	121072.		
45318 DEWARS/FITTING	2	6084.	12168.		
45319 MANIFOLD	1	117.	117.		
45320 RELIEF VENT VALVE	1	191.	191.		
45321 FILL VALVE MAN	1	220.	220.		
45322 SOLENOID S/O VALVE	1	704.	704.		
45323 GROUND SERVICE LN2	1	401.	401.		
45324 FILL LINE	1	28.	28.		
45325 QUANTITY SENSOR	2	102.	204.		
45326 PRESSURE SENSOR	1	64.	64.		
45327 MAIN DISTRIBUTION LINE HPE	1	129.	129.		
45328 ON STAGE DEMAND REG LPD	1	949.	949.		
45329 SCRUB HX	1	440.	440.		
45330 SOLENOID VALVE LPD	1	218.	218.		
45331 ORIFICE FITTINS LPD	1	54.	54.		
45332 CLIMB/DIVE VALVE	1	1109.	1109.		
45333 SCRUB NOZZLES LPD	6	504.	3024.		
45334 CHECK VALVES LPD	2	67.	134.		
45335 CONTROLLER-BIT	1	10444.	10444.		
SUBTOTAL				161408.	
WARRANTY(1%)				1614.	
HARDWARE PER SHIP SET				163022.	
TOTAL HARDWARE (750 SHIP SETS)				122266600.	
SUPPORT INVESTMENT				22151390.	
INITIAL SPARES COST			4268139.		
INITIAL SUPPORT EQUIPMENT			10662900.		
INITIAL TRAINING (3 OZ OF TOTAL ACQUISITION)			7665997.		
TECHNICAL PUBLICATION			2554473.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					111440460.
CONDEMNATION SPARES			6977657.		
ON EQUIPMENT MAINTENANCE			5173663.		
OFF EQUIPMENT MAINTENANCE			25722120.		
INTERMEDIATE		22134029.			
DEPOT		2584276.			
TRANSPORTATION		1003992.			
INVENTORY MANAGEMENT			52767.		
SUPPORT EQUIPMENT			21375000.		
PERSONNEL TRAINING			565715.		
MANAGEMENT & TECHNICAL DATA			744158.		
FUEL CONSUMPTION			48990600.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					268300440

LIFE CYCLE COST REPORT [illegible]

RESEARCH AND DEVELOPMENT					[illegible]
HARDWARE ACQUISITION					[illegible]
[illegible]				[illegible]	
43410 [illegible]	[illegible]	[illegible]	[illegible]		
43411 [illegible]	[illegible]	[illegible]	[illegible]		
43412 [illegible]	[illegible]	[illegible]	[illegible]		
43413 [illegible]	[illegible]	[illegible]	[illegible]		
43414 [illegible]	[illegible]	[illegible]	[illegible]		
43415 [illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]		
43420 [illegible]	[illegible]	[illegible]	[illegible]		
43421 [illegible]	[illegible]	[illegible]	[illegible]		
43422 [illegible]	[illegible]				
43423 [illegible]	[illegible]	[illegible]	[illegible]		
SUBTOTAL				[illegible]	
WARRANTY(13)				[illegible]	
HARDWARE PER SHIP SET				[illegible]	
TOTAL HARDWARE (750 SHIP SETS)				[illegible]	
SUPPORT INVESTMENT				[illegible]	
INITIAL SPARES COST			[illegible]		
INITIAL SUPPORT EQUIPMENT			0		
INITIAL TRAINING (3.0% OF TOTAL ACQUISITION)			[illegible]		
TECHNICAL PUBLICATION			[illegible]		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					53765856.
CONDEMNATION SPARES			815497.		
ON-EQUIPMENT MAINTENANCE			6200138.		
OFF-EQUIPMENT MAINTENANCE			45243390.		
INTERMEDIATE		43953320.			
DEPOT		1092666.			
TRANSPORTATION		157401.			
INVENTORY MANAGEMENT			273285.		
SUPPORT EQUIPMENT			0.		
PERSONNEL TRAINING			1019748.		
MANAGEMENT & TECHNICAL DATA			205791.		
FUEL CONSUMPTION			0.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					189201900.

LIFE CYCLE COST REPORT STORED GAS, 1500 UNITS

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					13047000.
HARDWARE ACQUISITION:					317609400.
45000 PERMEABLE MEMBRANE 166				195301.	
45510 PRE COOLER	1	1797.	1797.		
45511 PRESS REG/SHUTOFF VAL	1	1549.	1549.		
45512 CREW SERVE PRIMARY HX	1	1458.	1458.		
45513 PRE COOLER TEMP CONT VL	1	1376.	1376.		
45514 TEMP SENSOR	1	108.	108.		
45515 DUCTING	1	3110.	3110.		
45516 WIRING & MISC	1	568.	568.		
45517 ECS	1	112869.	112869.		
45518 SOLENOID VAL	1	349.	349.		
45519 CREW SER SEC HX	1	800.	800.		
45520 WATER EXTRACTOR	1	50.	50.		
45521 PRISM UNITS	1	3375.	3375.		
45522 DUCTING FITTING	1	376.	376.		
45523 FLOW CONTROL VALVE	1	608.	608.		
45524 COMPRESSOR & MOTOR & INTERCOOLERS	1	25237.	25237.		
45525 HIGH PRESSURE BOTTLE & FITTING	2	10447.	20894.		
45526 HIGH PRESS. GROUND SERVICE CONNECT	1	349.	349.		
45527 ORIFICE/FITTING	1	50.	50.		
45528 HIGH PRESSURE REGULATOR	1	1200.	1200.		
45529 SOLENOID SHUTOFF VALVE	2	569.	1138.		
45530 MANUAL SHUTOFF VALVE	1	202.	202.		
45531 CONDENSATION DRAIN/VALVING	1	202.	202.		
45532 CHECK VALVE	1	71.	71.		
45533 PRESSURE SENSOR	3	86.	258.		
45534 TEMP SENSOR	1	108.	108.		
45535 O2 SENSOR	1	108.	108.		
45536 FLOW SENSOR	1	155.	155.		
45537 CONTROLLER/BIT	1	9608.	9608.		
45538 DUCTING	1	214.	214.		
45539 HP RELIEF VALVE	1	71.	71.		
45540 SOLENOID VAL	1	201.	201.		
45541 ORIFICE/FITTING	1	50.	50.		
45542 DEMAND REGULATOR	1	1020.	1020.		
45543 CLIMB DIVE/VALVE	1	1020.	1020.		
45544 SCRUB NOZZLES	1	202.	202.		
45546 CHECK VALVE	2	72.	144.		
45547 BOOST COMPRESSOR, ELECT MOTOR	1	3810.	3810.		
45548 BOOST COMPRESSOR AFTER COOLER	1	556.	556.		
SUBTOTAL				195301.	
WARRANTY(1%)				1953.	
HARDWARE PER SHIP SET				197254.	
TOTAL HARDWARE (1500 SHIP SETS)				295881000.	
SUPPORT INVESTMENT				22008390.	
INITIAL SPARES COST			9577530.		
INITIAL SUPPORT EQUIPMENT			0.		
INITIAL TRAINING (3.0% OF TOTAL ACQUISITION)			8876431.		
TECHNICAL PUBLICATION			3554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					213798500.
CONDEMNATION SPARES			807884.		
ON-EQUIPMENT MAINTENANCE			7362280.		
OFF-EQUIPMENT MAINTENANCE			199522900.		
INTERMEDIATE		195910300.			
DEPOT		3107904.			
TRANSPORTATION		504740.			
INVENTORY MANAGEMENT			1120100.		
SUPPORT EQUIPMENT			0.		
PERSONNEL TRAINING			4129199.		
MANAGEMENT & TECHNICAL DATA			856090.		
FUEL CONSUMPTION			0.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					546729900.

LIFE CYCLE COST REPORT ON DEMAND, 1500 UNITS

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					14915000.
HARDWARE ACQUISITION:					297589100.
45000 PERMEABLE MEMBRANE 1G6				182942.	
45110 PRE COOLER	1	4065.	4065.		
45111 PRESS REG/SHUTOFF VAL	1	1720.	1720.		
45112 CREW SERVE PRIMARY HX	1	3170.	3170.		
45113 PRE COOLER TEMP CONT VL	1	1549.	1549.		
45114 TEMP SENSOR	1	108.	108.		
45115 DUCTING	1	7402.	7402.		
45116 WIRING	1	604.	604.		
45117 ECS	1	121183.	121183.		
45118 SOLENOID VAL	1	947.	947.		
45119 CREW SER SEC HX	1	3472.	3472.		
45120 WATER EXTRACTOR	1	92.	92.		
45121 PRISM 100	5	3971.	19855.		
45122 DUCTING	1	851.	851.		
45123 SOL VAL ORIFICES	4	648.	2592.		
45124 ORIFICE/FITTING	1	50.	50.		
45125 PRESSURE SENSOR	2	94.	188.		
45126 FLOW SENSOR	5	111.	555.		
45127 O2 SENSOR	5	94.	470.		
45128 TEMP SENSOR	2	20.	40.		
45129 CONTROLLER/BIT	1	9608.	9608.		
45130 DUCTING	1	1214.	1214.		
45131 SOLENOID VAL	1	231.	231.		
45132 ORIFICE	1	50.	50.		
45133 DEMAND REGULATOR	1	1020.	1020.		
45134 CLIMB DIVE/VALVE	1	1020.	1020.		
45135 SCRUB NOZZLES	1	648.	648.		
45136 CHECK VALVE	2	134.	268.		
SUBTOTAL				182942.	
WARRANTY(1%)				1829.	
HARDWARE PER SHIP SET				184771.	
TOTAL HARDWARE (1500 SHIP SETS)				277157100.	
SUPPORT INVESTMENT				20432010.	
INITIAL SPARES COST			8547847.		
INITIAL SUPPORT EQUIPMENT			0.		
INITIAL TRAINING (3.0% OF TOTAL ACQUISITION)			8314714.		
TECHNICAL PUBLICATION			3554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					110565700.
CONDEMNATION SPARES			2577341.		
ON-EQUIPMENT MAINTENANCE			9298248.		
OFF-EQUIPMENT MAINTENANCE			95013920.		
INTERMEDIATE		91593380.			
DEPOT		2718654.			
TRANSPORTATION		704863.			
INVENTORY MANAGEMENT			783210.		
SUPPORT EQUIPMENT			0.		
PERSONNEL TRAINING			2033492.		
MANAGEMENT & TECHNICAL DATA			869670.		
FUEL CONSUMPTION			0.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					423069?00.

LIFE CYCLE COST REPORT LIQUID NITROGEN 1500

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					12442000.
HARDWARE ACQUISITION:					264322800.
45000 PERMEABLE MEMBRANE IGG				0.	
SUBTOTAL				0.	
WARRANTY(1%)				0.	
HARDWARE PER SHIP SET				0.	
23000 LIQUID NITROGEN CONSUMPTION				148498.	
45210 PRE COOLER BAS	1	1685.	1685.		
45211 PRESS REG/SHUTOFF VAL BAS	1	1549.	1549.		
45212 TREM SERVE PRIMARY HI BAS	1	800.	800.		
45213 PRE COOLER TEMP CONT VL BAS	1	1376.	1376.		
45214 TEMP SENSOR BAS	1	108.	108.		
45215 DUCTING /MSC BAS	1	2863.	2863.		
45216 WIRING & MISC BAS	1	586.	586.		
45217 ECS	1	111386.	111386.		
45219 DEMAPS/FITTING	2	5597.	11194.		
45218 MANIFOLD	1	108.	108.		
45220 RELIEF VENT VALVE	1	167.	167.		
45221 FILL VALVE MAN	1	202.	202.		
45222 SOLENOID S/O VALVE	1	648.	648.		
45223 GROUND SERVICE LN2	1	369.	369.		
45224 FILL LINE	1	26.	26.		
45225 QUANTITY SENSOR	2	94.	189.		
45226 PRESSURE SENSOR	1	59.	59.		
45227 MAIN DISTRIBUTION LINE MFD	1	119.	119.		
45228 ON STAGE DEMAND REG LPD	1	873.	873.		
45229 SCRUB HI	1	405.	405.		
45230 SOLENOID VALVE LPD	1	201.	201.		
45231 OFFICE FITTING LPD	1	50.	50.		
45232 CLIMB/DIVE VALVE	1	1020.	1020.		
45233 SCRUB NOZZLES LPD	6	464.	2784.		
45234 CHECK VALVES LPD	2	62.	124.		
45235 CONTROLLER/BIT	1	9608.	9608.		
SUBTOTAL				148498.	
WARRANTY(1%)				1485.	
HARDWARE PER SHIP SET				149983.	
TOTAL HARDWARE (1500 SHIP SETS)				224974500.	
SUPPORT INVESTMENT				39346350.	
INITIAL SPARES COST			7719684.		
INITIAL SUPPORT EQUIPMENT			21325600.		
INITIAL TRAINING (2.5% OF TOTAL ACQUISITION)			6749234.		
TECHNICAL PUBLICATION			3554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					222086100.
CONDEMNATION SPARES			16248770.		
ON-EQUIPMENT MAINTENANCE			10257330.		
OFF EQUIPMENT MAINTENANCE			51205990.		
INTERMEDIATE		44935470.			
DEPOT		5099696.			
TRANSPORTATION		2047765.			
INVENTORY MANAGEMENT			256000.		
SUPPORT EQUIPMENT			42651000.		
PERSONNEL TRAINING			1137832.		
MANAGEMENT & TECHNICAL DATA			683349.		
FUEL CONSUMPTION			97144005.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					498850900.

LIFE CYCLE COST REPORT HALON 1500.

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					11556000.
HARDWARE ACQUISITION:					241287600.
23000 HALON CONSUMPTION				0.	
SUBTOTAL				0.	
WARRANTY(1%)				0.	
HARDWARE PER SHIP SET				0.	
45000 PERMEABLE MEMBRANE 166				146292.	
45210 PRE COOLER BAS	1	1685.	1635.		
45211 PRESS REG/SHUTOFF BAS	1	1549.	1549.		
45212 CREW SERVE PRIMARY HX BAS	1	1784.	1284.		
45213 PRE COOLER TEMP CONT VL	1	1376.	1376.		
45214 TEMP SENSOR BAS	1	108.	108.		
45215 DUCTING BAS	1	2863.	2863.		
45216 WIRING & MISL BAS	9	44.	396.		
45217 ECS	1	111386.	111396.		
45218 STORAGE BOTTLES	2	4333.	8666.		
45219 FILLER VALVE-RES	1	207.	202.		
45220 GROUND SERVICE CONNECTION	1	369.	369.		
45221 SOLENOID VALVE S/O VALVE	1	649.	648.		
45222 FILL LINE	1	26.	26.		
45223 PRESSURE SENSOR	1	108.	108.		
45224 QUANTITY SENSOR	2	94.	188.		
45225 RELIEF VALVE	1	71.	71.		
45226 CONTROLLER BIT	1	9608.	9608.		
45227 HIGH PRESSURE REGULATOR HPD	1	1200.	1200.		
45228 FLOW CONTROL HPD	1	835.	835.		
45229 BLEED AIR SUPPLY DUCTING HPD	1	348.	348.		
45230 ORFICE-FITTING	1	50.	50.		
45231 DUCTING/FITTING HPD	1	1131.	1131.		
45232 DEMAND REGULATOR LPD	1	1020.	1020.		
45233 CLIMB/DIVE VALVE LPD	1	1020.	1020.		
45234 CHECK VALVE LPD	1	155.	155.		
SUBTOTAL				146292.	
WARRANTY(1%)				1463.	
HARDWARE PER SHIP SET				147755.	
TOTAL HARDWARE (1500 SHIP SETS)				221632400.	
SUPPORT INVESTMENT				19655190.	
INITIAL SPARES COST			7394389.		
INITIAL SUPPORT EQUIPMENT			2057400.		
INITIAL TRAINING (.03% OF TOTAL ACQUISITION)			6648972.		
TECHNICAL PUBLICATION			3554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					1655616000.
CONDEMNATION SPARES			1257567.		
ON EQUIPMENT MAINTENANCE			8273349.		
OFF-EQUIPMENT MAINTENANCE			89753240.		
INTERMEDIATE		85598780.			
DEPOT		279,510.			
TRANSPORTATION		369124.			
INVENTORY MANAGEMENT			714539.		
SUPPORT EQUIPMENT			4114600.		
PERSONNEL TRAINING			1515912.		
MANAGEMENT & TECHNICAL DATA			595892.		
FUEL CONSUMPTION			940796000.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					[illegible]

LIFE CYCLE COST REPORT POAM, 1500 UNITS

	QTY	UNIT COST	TOTAL U.C.	SUBTOTAL	TOTAL
RESEARCH AND DEVELOPMENT					9550000.
HARDWARE ACQUISITION:					212079700.
45000 PERMEABLE MEMBRANE 166				129301.	
45410 PRE COOLER BAS	1	1685.	1685.		
45411 PRESS REG/SHUTOFF VAL BAS	1	1549.	1549.		
45412 CHECK SERVE PRIMARY HX BAS	1	1285.	1285.		
45413 PRE COOLER TEMP CONT VL BAS	1	1376.	1376.		
45414 TEMP SENSOR BAS	1	108.	108.		
45415 DUCTING/FITTING BAS	1	2863.	2863.		
45416 WIRING & MISL	1	74.	74.		
45417 ECS	1	111700.	111700.		
45418 DUCTING HPD	1	446.	446.		
45419 ORFICE/FITTING HPD	1	50.	50.		
45420 DEMAND REGULATOR LPD	1	1073.	1073.		
45421 CLIMB/DIVE VALVE LPD	1	1073.	1073.		
45422 CHECK VALVE LPD	1	71.	71.		
45423 FOAM	1	5940.	5940.		
SUBTOTAL				129301.	
WARRANTY(1%)				1293.	
HARDWARE PER SHIP SET				130594.	
TOTAL HARDWARE (1500 SHIP SETS)				195891000.	
SUPPORT INVESTMENT				16188740.	
INITIAL SPARES COST			6757579.		
INITIAL SUPPORT EQUIPMENT			0.		
INITIAL TRAINING (3.0% OF TOTAL ACQUISITION)			5876730.		
TECHNICAL PUBLICATION			3554433.		
FACILITIES COST			0.		
SPARE ENGINES COST			0.		
OPERATING AND SUPPORT COST(20.0 YEARS)					106871200.
CONDEMNATION SPARES			1491619.		
ON-EQUIPMENT MAINTENANCE			12416200.		
OFF-EQUIPMENT MAINTENANCE			90122170.		
INTERMEDIATE		87646500.			
DEPOT		2160861.			
TRANSPORTATION		314802.			
INVENTORY MANAGEMENT			390105.		
SUPPORT EQUIPMENT			0.		
PERSONNEL TRAINING			2039496.		
MANAGEMENT & TECHNICAL DATA			411581.		
FUEL CONSUMPTION			0.		
SOFTWARE SUPPORT			0.		
TOTAL LIFE CYCLE COST					328501000.

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